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in Physical Education, sport and recreation

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FOREWORD

Faculty of Sport and Physical Education University of Nis in its 47 years long tradition organizes a scientific conference "FIS COMMUNICATIONS". This year we are organizing 21st scientific conference "FIS COMMUNICATIONS 2018". Our profound years long experience in organizing of the conference has contributed to ever increasing high quality of the conference over years.

International scientific conference "FIS COMMUNICATIONS 2018" is organized by the Faculty of sport and Physical Education University of Nis under the auspices of the Ministry of Education, Science and Technological Development of the Republic of Serbia.

We are proud to announce the key speakers in our plenary sessions as eminent renowned experts in their field of expertise who are coming from the countries taking part in this conference more then once.
This conference can boast submission of 70 full text papers. Upon the review process 60 papers were accepted and approved for the publication. Papers are divided into four sessions depending on the topics investigated as follows: Individual and Team Sports, Physical Education, Interdiciplinary and Poster session.

Organizers are satisfied with the participation of already renowned researchers and the young, oncoming authors following the thorny path of the scientific investigation, as well. Also a large number of foreign authors and thematic diversity have widen the horizon of the expert and scientific insights, put some new incentive for the cooperation and expression of the new creative efforts.

Enclosed you can find the Proceedings of the International scientific conference "FIS COMMUNICATIONS 2018" incorporating all the papers presented at the scientific conference. We would like to express our gratitude to all the participants, especially to the authors of the papers and we expect that all this conference contributes to enhance and further the development of the scientific and expertise thought in the area of sport, physical education and recreation.

Chair of the Scientific Committee
Miodrag Kocić, PhD, prof.

CONTENTS

Plenary Sesion

HAMSTRING INJURY PREVENTION AND REHABILITATION

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UDC 616.001:615.8:796.01

SUMMARY

Hamstring injury represents one of the most important injuries in sports that involve explosive actions such as soccer and sprinting. The aim of this presentation is to provide the latest information regarding injury mechanisms and subsequent rehabilitation. Particularly, inter- and intra-muscular variations between the hamstring muscle components appears to play an important role for injury occurrence, prevention and rehabilitation. There is a debate on the best practices for injury prevention; currently, programs that involve eccentric exercise appear particularly effective. Similarly, rehabilitation interventions involving eccentric exercise at longer lengths and trunk stabilization are the only ones that appear particularly effective.

Keywords: Sport injury; Return to play; biceps femoris long head; muscle.

INTRODUCTION

Hamstring muscle strains are one of the most frequent injuries in sports with a prevalence ranging from 8% to 25% (Opar, Williams, & Shield, 2012; Prior, Guerin, & Grimmer, 2009), depending on injury mechanism and type of sport. More importantly, such injury displays a greater recurrence rate, which is in the range of 30% or greater (Brooks, Fuller, Kemp, & Reddin, 2006; Ekstrand et al., 2012) . The purpose of this presentation is to specifically examine latest research on the architecture and mechanical properties of the hamstrings and their implications for injury and rehabilitation.

Hamstring injury mechanisms: the debate continues

Numerous factors have been proposed for causing hamstring injury, ranging from age and muscle morphology to the actual game or weather conditions (Opar et al., 2012). Nevertheless, the mechanisms that lead to injury and the subsequent rehabilitation remain unclear with different and, sometimes, controversial views expressed in the literature (Garrett, Safran, Seaber, Glisson, & Ribbeck, 1987; Herzog, 2017; Liu, Sun, Zhu, & Yu, 2017; Mendiguchia, Alentorn-Geli, & Brughelli, 2012; Nikolaou, Macdonald, Glisson, Seaber, & Garrett Jr., 1987; Yu, Liu, & Garrett, 2017b, 2017a). Most of these views are mainly related to the way the hamstrings respond to high loading conditions, such as when they are stretched over a long period of time or they resist forced active lengthening over brief periods of time. In addition, injury risk varies significantly between individual hamstring components (Koulouris & Connell, 2003, 2006; Verrall, Slavotinek, Barnes, Fon, & Spriggins, 2001). This raises questions whether specific movements can lead to injury of specific hamstring muscles; conversely, one may wonder whether specific intervention strategies can be used to prevent specific hamstring muscles from getting injured.

Architecture can explain hamstring injury mechanisms

Despite the identified need for managing hamstring injuries, there is not enough information on the fundamental properties of the hamstrings. For example, the implications from the differences in architecture between individual hamstrings are currently not being understood (Kellis, 2018b). Yet, it is clear, that the biceps femoris muscle is by far the most likely muscle to sustain injury compared with the rest hamstrings. Currently, there is enough evidence to suggest that the biceps femoris has different tendon and fascicle properties than the other hamstrings and this is likely to contribute to its higher susceptibility to injury (Kellis, 2016, 2018a).

Evidence indicates that the main mechanism of hamstring muscle injury is excessive lengthening during fast sprint movements or slow dancing movements (Liu et al., 2017; Nikolaou et al., 1987; Yu et al., 2017b). The greater injury episodes for the biceps femoris long head compared with the other muscles may be related to a greater relative lengthening of this muscle, a reduced capacity to withstand high forces at these long lengths and, perhaps, an altered activation pattern (Kellis, 2018a; Kellis, Galanis, Chrysanthou, & Kofotolis, 2016).

Injury prevention

Amongst the factors that can be modified and prevent injury, strength and flexibility are the most important ones. Nevertheless, the significance of these factors either independently or in combination with other factors is not fully supported in the literature (Opar et al., 2012; Prior et al., 2009). This places some doubt on the value of strength and flexibility tests for predicting muscle injuries. Nevertheless, it appears evident that athletes which display very high bilateral strength differences or very low H:Q ratios are more likely to get injured. However, there is some evidence that athletes with a selective reduction of strength at longer muscle lengths, shorter fascicles and lower activation of the hamstrings may have a higher risk for injury (Timmins et al., 2016). However, much more evidence is necessary to support such a concept (Schuermans, Van Tiggelen, & Witvrouw, 2017).

Rehabilitation

Research studies have identified that eccentric training and progressive agility and trunk exercises may have some advantages over other forms of training for hamstring injury rehabilitation (Heiderscheit, Sherry, Silder, Chumanov, & Thelen, 2010). It becomes clear, however, that restoration of architecture and mechanics represent an important aim of the rehabilitation following hamstring injury (Kellis, 2018b; Kellis et al., 2016). Inclusion of co-contraction exercises may assist in better controlling the knee at the terminal phase of sprinting phase (Kellis, 1998) but it is unclear how this can apply to hamstring rehabilitation. Third, the role of tendinous tissue adaptations to hamstring injury and rehabilitation should be clarified (Askling, Tengvar, Tarassova, & Thorstensson, 2014; Brukner & Connell, 2016). Managing chronic pain or fear of pain in those individuals who display recurrent injuries may also be “key” factor for a successful recovery and this should be investigated further.

CONCLUSION

There has been a major progress in identifying, understanding and treating hamstring injuries. This presentation specifically focused on the architecture and mechanics of hamstrings and their implications for injury and rehabilitation. Due to inter- and intra-muscular differences in mechanical properties, it becomes evident that hamstrings exercises do not recruit all individual hamstrings in the same way. Similarly, injury prevention and rehabilitation programs, such as eccentric exercises at longer lengths, are designed to restore architecture and mechanical behavior of the muscles to pre-injury levels.

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THE POTENTIAL OF TENSIOMYOGRAPHY TO MEASURE MUSCLE ASYMMETRIES

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SUMMARY

Skeletal muscle's intrinsic mechanical contractile properties are of interest in many fields (e.g. sport training, rehabilitation, sport and medical diagnostics, research, ageing). They have been assessed using dynamometer, since its invention back in the 18th century, although there are several issues that diminish the quality of the interpretation of dynamometry results. Slovenia played a marginal role in this quest with tensiomyography (TMG) that measures contractile properties through detection of skeletal muscle belly thickening, vibration and bulk movement during twitch isometric contraction in selective and non-invasive way. Since the first TMG publication back in 1990 several improvements have emerged with over 110 SCI publications, rising exponentially. Although the TMG method is generally accepted, it rises several important questions: (i) what is the distinction between TMG and dynamometry, as both methods are assessing mechanical contractile properties; (ii) how is the TMG amplitude related to muscle contractile properties; (iii) How is the shape of the TMG curve related to muscle contractile properties; (iv) what is the predictive value of TMG results on sport and health parameters. TMG underwent a series of thorough validation studies to provide enough scientific evidences and become an accepted method in different fields. Even more, the state-of-the-art potential of TMG (or even above it) is its instalment in monitoring sarcopenia, early atrophy dynamics, fatigue/potentiation, and prediction of health events (e.g. injuries). We will present findings from most recent studies on the effects of development, disuse, rehabilitation and ageing on TMG-derived contractile parameters. Furthermore, we will present the contradictory results obtained in fatigue studies supporting possible sensitivity of TMG parameters to different fatigue modalities. We will also focus on predictive value of muscle asymmetries on injury incidence in sport and occupational health. The most recent basic research activities are focusing on a decomposition of TMG response to three different mechanical responses originating from three muscle phenotypes (slow, fast-oxidative and fast-glycolytic). The decomposition is based on different exponential-shaped mathematical curves, each with three parameters representing variance in physiological parameters of single fibres, summating to a best fit in comparison to original TMG response. We will demonstrate decomposition results (content validity) from various TMG studies: potentiation, fatigue, rehabilitation and atrophy. Our results (so far) confirm the logic of 3-component linear decomposition of TMG responses in abovementioned studies. And by this it also emphasizes the correctness of TMG approach, to detect muscle belly thickening rather than longitudinal shortening, to study intrinsic skeletal muscle contractile parameters. And this is important to understand that the heterogeneity of a muscle composition plays an important role in whole muscle contractile properties that is not evident from dynamometric assessment, but it is from TMG assessment.

Individual and Team Sports

HANDGRIP DIFFERENCES BETWEEN YOUNG KARATE ATHLETES AND NON-ATHLETES IN RELATION TO GENDER

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UDC 796.85:613.25

SUMMARY

Handgrip is positively established marker for evaluation of body strength in general. Even though several recent studies in combat sports have highlighted the role of handgrip force (HGF) in sports achievement, the impact of training, in particular in karate, on development of the HGF parameters in children before puberty has not been sufficiently explored. Having regard to these issues, the present study aimed to reveal existence of contractile differences in male and female preadolescents i.e. karate athletes and non-athletes in relation to activity. A total of 219 children (Male n = 125, karate athletes = 73, non-athletes = 52; Female n = 94, karate athletes = 48, non-athletes = 46), age from 10 to 13 years, participated in the study. Both hands, dominant and non-dominant, were tested using the standard handgrip test and the highest value from two trials was used to determine the maximal isometric handgrip force (F_{max}) and the maximal rate of force development (RFD). Multivariate analysis of variance (MANOVA) revealed the existence of differences between karate athletes vs. non-athletes in male subjects ($F=5.07$; $p<0.000$; $\eta^2=0.27$), as well as in female subjects ($F=4.84$; $p<0.000$; $\eta^2=0.33$) at general level. The results are indicating that there are no statistically significant differences between male karate athletes and non-athletes regarding F_{max}, but higher values of RFD are evidenced in favor to non-athletes in both absolute and relative terms. Girls training karate achieve statistically higher values of F_{max}, but only in right hand both absolute and relative terms, while there are no differences when it comes to the left one. When it comes to RFD, evidence favors non-athletes in absolute terms. The results are most probably indicating that differences in RFD regarding boys and girls occurs as a consequence of a non-adequate intermuscular coordination caused by basic karate training. On the contrary to that, positive effect of training is evident in girls, but only when it comes to maximal force.

Keywords: karate, isometric handgrip force, preadolescents, activity level

INTRODUCTION

It is well known that biological maturity in preadolescents, both male and female, is positively related to isometric strength (Beunen & Thomis, 2000). Diversity of studies have been conducted in regard to handgrip force (HGF) in children and it's relation to anthropometry, body composition (Jürimäe at al., 2009), physical fitness and health (Ortega et al., 2008). In compare to that, the impact of sports (in particular karate) on development of the maximal handgrip force and rate of force development (RFD) in children before puberty, have not been sufficiently explored.

Research up to date have shown that handgrip is positively established marker for evaluation of body strength in general (Norman et al., 2011; Wind et al., 2010; Ivanović & Dopsaj, 2012; Dopsaj et al. 2009) as well as overall health (Cohen et al., 2011). Therefore it has been suitable in various types of epidemiological (Leong et al., 2015) and clinical studies (Norman et al., 2011). Also, it has been noted that hand functional properties are key performance indicator in some sports, such as, climbing, tennis, gymnastics, boxing and so (Cronin et al., 2017; Falahi & Jadidian, 2011). Hence, being easy to apply (Ivanović & Dopsaj, 2012) hangrip tests are frequently used as a valid tool for assessing a level of important parameters which determine sports achievement (Cronin et al., 2017; Dopsaj et al., 2011).

Several recent studies in combat sports have highlighted the role of handgrip force in that matter. Statistically significant differences have been established in HGF parameters of wrestlers in comparing to control group of moderately active people. Researchers have come to conclusion that wrestlers have higher level of maximum and explosive force in absolute as well as in relative terms (Marković et al., 2016). Surprisingly, research have shown that HGF may not be as important aspect of discrimination in judo and non-judo practitioners. No significant effect has been detected regarding influence of judo practice on the grip force peak in absolute terms comparing judokas to non-judokas (Dias et al., 2012).

Speaking of karate, there is a lack of literature data that reveal the influence of training on HGF, or the role of it in sports achievement. Especially when it comes to children. Comparing karate, judo, wrestling, taekwondo and aikido athletes to the team sports and non-athletes adolescents it has been found that martial arts athletes achieve lower values of handgrip isometric strength, although this difference is not statistically significant (Kayihan, 2014). Yet, it has been determined that dynamic as well as statis grip strength indicators (at eighteen-year-olds) are 1.5 to 4 times bigger in combat sports as Greco-Roman and free style wrestling, judo and sambo than in hand-to-hand combat, karate or taekwondo (Iermakov et al., 2016). Although there are differences between highly trained taekwondo, judo and karate athletes U13 and U18 in general physical level in regard to sport discipline, only among older group statistically significant differences are found when it comes to HGF in favor to judo (Pion et al., 2014). Monitoring developmental trends of the contractile properties of handgrip muscle force in U11, U13, cadet, junior and senior male karate athletes in Serbia, Koropanovski et al., (2016) came to conclusion that trend of increase in maximal HGF both left and right, as well as summary value for both hands in relation to age expressed by indexes, is 83.78N, 80.71N and 164.49N applicable to all age groups.

As shown above, research in the field of HGF have been mostly focused on differences between martial arts athletes in relation to level of practice or type of combat sport. Just a very few deal with the changes in a HGF parameters under the influence of training, especially in preadolescents. There is also a lack of comparative research among martial arts athletes and non-active population at the same age group. Having regard to these issues the present study aimed to reveal existence of contractile differences of the hand (maximal force and maximal rate of force development in absolute and relative terms, respectively) between male and female preadolescents in relation to activity i.e. karate athletes and non-athletes.

METHODS

Subjects

A total of 219 children (Male n = 125, karate athletes = 73, non-athletes = 52; Female n = 94, karate athletes = 48, non-athletes = 46) participated in the study (Table 1). Participants ranging in age from 10 to 13 years were divided in two categories according to the activity level. Active children were recruited from a single Belgrade karate club and have been involved on a regular basis in training process for at least 3 years. Control group consisted of inactive healthy schoolchildren who have not been involved in sport of any kind or practicing regularly. None of the participants reported any condition that interfered with normal function of the hand.

The study was conducted following the ethical standards recognized by the Declaration of Helsinki and was approved by the Ethics research Committee of the Faculty of Sport and Physical Education, University of Belgrade.

Table 1 Physical characteristics of male and female karate athletes and non-athletes (Mean ± SD) in general.

Gender	Activity	n	Age (years)	Body mass (kg)	Height (cm)	BMI (kg/m^2)
Male	Karate athletes	73	11.80 ± 1.19	45.84 ± 10.02	156.79 ± 11.36	18.52 ± 2.63
	Non-athletes	52	11.42 ± 1.16	47.00 ± 13.32	155.00 ± 13.45	19.25 ± 3.27
Female	Karate athletes	48	11.86 ± 1.23	42.40 ± 9.24	152.97 ± 18.08	17.75 ± 2.77
	Non-athletes	46	11.83 ± 1.10	44.54 ± 9.44	155.98 ± 10.43	18.12 ± 2.24

Procedure

The same experienced examiners conducted field testing using the standard handgrip test (Dopsaj et al., 2009; Ivanović & Dopsaj, 2012). Participants were given five minutes to warm up. Both hands, dominant and non-dominant, were tested. After they were familiarized with the testing procedure, participants performed two trials with each hand. Rest period between the trials lasted at least one minute. The participants were sitting on the chair with their knees bent at an angle of 90 degrees, back straight and feet flat on the floor. Arm with the hand holding measuring device rested alongside and approximately 10 cm away from the body. The participants were instructed to, after given a voice signal by the examiners, squeeze the measuring device with the probe as hard as possible. Maximal isometric contraction lasted no longer than 4 to 5 seconds. The highest value from two trials was used to determine the maximal isometric handgrip force (N) and the maximal rate of force development (N/s).

The contractile characteristics of hand grip muscle force were assessed using variables as follows:

1. F_{max} – the maximal value of isometric handgrip muscle force achieved (both the right – F_{maxR} and left – F_{maxL} hand) expressed in Newtons (N)
2. RFD_{max} – the maximal value of rate of force development achieved (both the right – RFD_{maxR} and left – RFD_{maxL} hand) expressed in Newton/second (N/s)
3. F_{rel} – the relative value of muscle force (both the right – F_{relR} and left – F_{relL} hand)
4. RFD_{rel} – the relative value of rate of force development (both the right – RFD_{relR} and left – RFD_{relL} hand).

Statistical analysis

To provide basic summaries about the sample and tested variables descriptive statistics was used: average value (MEAN), standard deviation (SD), coefficient of variation (cV%), Minimum (MIN) and Maximum (MAX). Multivariate analysis of variance (MANOVA) was performed in order to explore differences among tested variables in relation to gender and activity level, whilst the Bonferroni correction was applied to pairwise comparisons of HGF parameters for male and female in relation to activity. All statistical analysis were performed using the computer software packages Microsoft Office Excel 2007 and IBM SPSS Statistics 20. Significance level was set at $p \leq 0.05$.

RESULTS

Table 2 summarizes results of the basic descriptive statistics of HGF parameters for male subjects, separately for karate athletes and non-athletes. Results of HGF parameters for female subjects are presented in the same manner in Table 3. Results of Multivariate analysis of variance (MANOVA) of HGF parameters in relation to activity level for male and female subjects in general are shown in Table 4.

Table 2 Basic descriptive statistics of the HGF parameters for male karate athletes and non-athletes in general.

		F_{maxR} (N)	RFD_{maxR} (N/s)	F_{maxL} (N)	RFD_{maxL} (N/s)	F_{relR}	RFD_{relR}	F_{relL}	RFD_{relL}
Karate athletes (n=73)	Mean	216.90	1127.08	197.74	1026.68	4.74	24.60	4.32	22.48
	SD	60.88	473.93	60.13	439.42	0.86	8.43	0.85	8.11
	cV%	28.07	42.05	30.41	42.80	18.23	34.25	19.70	36.08
	Min	123.00	397.00	109.00	229.00	2.95	11.34	2.76	6.54
	Max	409.00	3275.00	396.00	3083.00	6.85	51.17	6.19	48.44
Non-athletes (N=52)	Mean	214.83	1415.37	208.29	1351.69	4.60	30.21	4.46	29.06
	SD	76.09	522.11	68.22	443.14	1.02	7.36	0.86	6.50
	cV%	35.42	36.89	32.75	32.78	22.24	24.36	19.37	22.37
	Min	109.00	537.00	105.00	674.00	2.48	14.74	2.57	17.91
	Max	413.00	2831.00	388.00	2435.00	7.31	46.91	6.56	44.02

The analysis revealed the existence of differences among karate athletes vs. non-athletes in male subjects ($F = 5.07$; $p < 0.000$; $\eta^2 = 0.27$), as well as in female subjects ($F = 4.84$; $p < 0.000$; $\eta^2 = 0.33$) at general level. The results of MANOVA on the partial level are summarized in Table 5. A series of post-hoc tests Bonferroni have shown that there are statistically significant differences ($p < 0.000$) in RFD_{max} as well as in RFD_{rel} both right and left hand in relation to activity for male subject. Statistically significant differences ($p < 0.05$) were also found in all HGF parameters excluding F_{maxL}, RFD_{relR} and RFD_{relL} for female subjects in relation to activity.

Table 3 Basic descriptive statistics of the HGF parameters for female karate athletes and non-athletes in general.

		F_{maxR} (N)	**RFD_{maxR} (N/s)**	**F_{maxL} (N)**	**RFD_{maxL} (N/s)**	**F_{relR}**	**RFD_{relR}**	**F_{relL}**	**RFD_{relL}**
Karate athletes (N=48)	Mean	211.45	1140.55	194.47	1044.42	4.93	26.66	4.53	24.42
	SD	57.15	421.15	52.25	380.29	0.87	8.37	0.82	7.68
	cV%	27.03	36.93	26.87	36.41	17.68	31.40	18.14	31.46
	Min	123.00	351.00	106.00	337.00	2.73	10.03	2.86	9.63
	Max	344.00	2158.00	307.00	1747.00	6.82	44.37	6.05	42.61
Non-athletes (N=46)	Mean	193.30	1278.89	184.08	1188.19	4.35	28.60	4.13	26.27
	SD	49.17	369.27	44.36	393.88	0.66	5.21	0.55	6.33
	cV%	25.44	28.87	24.10	33.15	15.09	18.23	13.25	24.09
	Min	119.00	606.00	92.00	1.00	2.58	16.71	3.00	0.03
	Max	292.00	2010.00	260.00	1897.00	6.24	37.88	5.19	39.33

Table 4 MANOVA results of tested variables for male and female in relation to activity.

Effect	**Gender**	**Wilks' Lambda Value**	**F**	**Hypothesis df**	**Error df**	***p* value**	**Partial Eta Squared**	**Observed Power**
Activity	Male	0.731	5.07	8.00	110.00	0.000	0.27	1.00
	Female	0.671	4.84	8.00	79.00	0.000	0.33	1.00

Table 5 Tests of Between-Subjects Effects for male and female in relation to activity.

Gender	**Dependent Variable**	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	***p* value**	**Partial Eta Squared**	**Observed Power**
Male	F_{maxR} (N)	352.20	1	352.20	0.14	0.707	0.001	0.066
	RFD_{maxR}(N/s)	3110460.83	1	3110460.83	19.21	0.000	0.141	0.992
	F_{maxL}(N)	7105.62	1	7105.62	3.20	0.076	0.027	0.427
	RFD_{maxL}(N/s)	3733632.50	1	3733632.50	27.92	0.000	0.193	0.999
	F_{relR}	0.34	1	0.34	0.42	0.520	0.004	0.098
	RFD_{relR}	1022.15	1	1022.15	16.95	0.000	0.127	0.983
	F_{relL}	0.96	1	0.96	1.40	0.238	0.012	0.217
	RFD_{relL}	1362.52	1	1362.52	25.21	0.000	0.177	0.999
Female	F_{maxR} (N)	7154.21	1	7154.21	4.52	0.036	0.050	0.556
	RFD_{maxR}(N/s)	409105.62	1	409105.62	4.97	0.028	0.055	0.597
	F_{maxL}(N)	2741.96	1	2741.96	1.89	0.172	0.022	0.275
	RFD_{maxL}(N/s)	401537.84	1	401537.84	4.89	0.030	0.054	0.590
	F_{relR}	6.82	1	6.82	11.85	0.001	0.121	0.926
	RFD_{relR}	114.02	1	114.02	2.89	0.093	0.033	0.391
	F_{relL}	3.67	1	3.67	7.88	0.006	0.084	0.793
	RFD_{relL}	86.26	1	86.26	2.17	0.145	0.025	0.307

DISCUSSION

The aim of the present study was to compare contractile characteristics of handgrip between karate athletes and non-athletes. The results presented above indicate that there are statistically significant differences between boys, in favor to non-athletes, but only regarding RFD values. Differences are confirmed both, absolute and relative terms. When it comes to girls, MANOVA revealed significant difference in F_{maxR} (in favor to karate athletes) and RFD (in favor to non-athletes) in absolute terms, but only differences in maximal force (in both, right and left hand) are confirmed as statistically significant in relative terms in favor to karate athletes.

Isometric muscle force increases linearly in relation to chronological age with some differences in regard to gender (Wind et al., 2010; Beunen & Thomis, 2000). In boys, a significant acceleration is recorded after 12 to 13 years of age, whears in girls linear trend is maintained up to 15th (Beunen & Thomis, 2000). Research confirms the differences in HGF between boys and girls after 10th year of age in favor to boys who become significantly stronger than girls (Häger-Ros & Rösbald, 2002). On the other hand, HGF differences in relation to activity are questionable. Although there are differences in level of physical fitness between athletes and non-athletes U13 in relation to gender according to Smoll and Schutz (1985), when it comes to handgrip, they are not significant. Absence of statistically significant differences in HGF in the sample of swimmers, tennis players and non-competitors up to 12 years of age is also reported in the research of Bloomfield et al. (1985). This leads to conclusion that impact of training at particular age, when it comes to boys, is not sufficient enough.

The results of the present study confirm these findings. Though the control group of the research showed higher average values of F_{max} in comparison to the young karate athletes in both absolute and relative terms (Table 2), further analysis showed that mean differences for F_{max} for both right and left hand, were not statistically significant (Table 5). Same age highly trained sample, in study of Pion et al. (2014) achieved somewhat lower, but also not statistically significant values of HGF: karate = 21 ± 5 kg, judo = 19 ± 4 kg, taekwondo = 20 ± 6 kg, which corresponds to the 206.01 ± 49.05 N, 186.39 ± 39.24 N and 196.2 ± 58.86 N, respectively. However, comparison with the results of Koropanovski et al. (2016) is not supporting these findings.

Namely, researchers evidenced high F_{max} values contradictory to our results, who lead to other possible explanations. It is likely that results were influenced by the lack of diversity of a sample in both cases. The sample of a present study is narrowed down to a single club. Except for this, the personality of boys who begin to exercise, as well as their motives for beginning karate practice must not be ignored. These assumptions are indicating that majority of practitioners are boys with low self-esteem. In this respect, it should also be kept in mind that low self-esteem in children is usually associated with poor motor skills (Piek et al., 2006) which could be the reason for lower values of F_{max}. The participants in study of Koropanovski et al. (2016), on the other hand, were selected national level competitors. In this regard, findings in mentioned study might question the dominant orientation in training with young selections, especially if compared to the results presented in study of Pion et al. (2014) mentioned above.

As for the girls, basic descriptive statistics of the HGF parameters are showing that karate athletes achieve significantly higher values of F_{max} for right hand 211.45 ± 57.15 N in comparison to their non-active counterparts 193.30 ± 49.17 N. They have on average 15% stronger right handgrip than non-athletes, while there are no statistically significant differences comparing results of F_{maxL} in absolute terms. In relative terms karate athletes achieve significantly higher values of HGF for both right and left hand with $p = 0.001$ and $p = 0.006$, respectively.

This kind of evidence is not surprising. Namely, it leads to conclusion that effect of training in comparison to anthropometric measures is more dominant in girls. Even though anthropometric measures are in strong correlation to the HGF (Häger-Ros, & Rösbald, 2002; Kljajić et al., 2012), differences occur when it comes to gender. Actually, biological maturity in preadolescent period has more influence in HGF measures in boys than in girls (Jones et al., 2000; Jürimäe et al., 2009). In that matter, body height as the most predictive anthropometric measure, explains the HGF with 76.1% and 50.6% in boys and girls, respectively (Jürimäe et al., 2009).

Unlikely F_{max}, statistically significant differences are verified in RFD for both left and right hand as well as for absolute and relative values in favor to male non-athletes. Like within the male subjects, non-trained female participants achieved better result in RFD in absolute terms for both right and left hand 1278.89 ± 367.27 N/s and 1188.19 ± 398.88 N/s, respectively but in relative terms differences have not been confirmed in favor to any group.

This is confusing, but only at first glance. Logical explanation might lie in the process of motor learning. During the phase of basic training, children are trying to overcome two tasks which seem to be non-complementary: to be relaxed and to hold a tightly clenched fist. Moreover, while performing the technique (i.e. punch), they learn to repeat a whole series of movements in a single continuous cycle involving rapid alternation in muscle contraction and relaxation. Trying to be "as fast and strong as possible", they unconsciously choose between these two. Non-adequate intermuscular coordination occurs as a consequence. At first, young practitioners tend not to develop movements in full range, become stiffer and slower. In other words, the nervous system receives opposite signals and in the process of rearranging priorities disrupts the natural reactions.

CONCLUSION

Returning to the main goal of the study, it is now possible to state that, differently from what it might be expected, male karate athletes do not necessarily develop higher level of force than non-karate athletes. Statistically significant difference in F_{max} occurs in girls, but only in right hand and it might be a result of training. When it comes to rate of force development, evidence favors male non-karate athletes in absolute and relative terms and female non-karate athletes in absolute terms.

Even so, HGF may be questioned as sufficiently reliable and sensitive parameter to distinguish groups of athletes and non-athletes in this developmental period in regard to karate. Meaning that some other motor ability tests might given more discriminatory results. Nevertheless, handgrip can provide valuable informations of overall health and condition in young karate athletes. In particular, the question of the psychological and motor profile of children who begin to practice karate is posed. However, more research needs to be undertaken before this association is more clearly understood. In that matter, handgrip test supported with tests of psychological personality profile might give an answer.

Present study have highlighted the issues regarding motor learning process during basic training, indicating possibile problems which are causing a delay in development of an adequate intermuscular coordination. From aspect of karate training system, it would be interesting and useful to provide a deeper insight into a particular matter. Dominant orientation in training preadolescents has also been argued. That is an important issue for future research which are required to determine whether high values in HG parameters in particular developmental period of karate athletes are desirable or not. That kind of research should involve broader and more diversity sample as well as comparison to other sports and non-athletes.

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ANTHROPOMETRY, STRENGTH, ENDURANCE AND FLEXIBILITY CHARACTERISTICS OF ELITE MALE ICE CLIMBERS AND IT'S COMPARISON WITH NON CLIMBING ATHLETES

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SUMMARY

Introduction: Purpose of this study was to compare elite male ice climbers and non climbers, their anthropometry, muscular strength, endurance and flexibility. The second aim was to extract variables which are specific for ice climbing and realize how they affect the competitive placement.

Methods: Participants were divided in two groups. First group consisted of 23 male ice climbers who competed at the Ice Climbing World Cup 2010 organized by UIAA in Saas Fee (Switzerland) and they all passed to the final round. The other group consisted of 23 athletes of same age but from different non climbing sports, such as: rowing, fitness, handball, hockey, basketball, water polo, karate and cycling. Measurements included anthropometry, three different tests for flexibility, two for strength and two endurance tests.

Results: Ice climbers has less height, mass, BMI, BMR and fat% in their body, comparing to non climbers. Ice climbers have significant less result for handgrip strength test in both hands, as well as SME, comparing to non climbers. Considering tests hip abduction and handgrip endurance, ice climbers shows significant better results.

Conclusion: Results indicate that ice climbers have smaller height, weight, BMI, body fat% and handgrip strength for both hands comparing to non climbing athletes. On the other side, ice climbers need to know that except for need to developing endurance, strength and flexibility as main preconditions; success at competitions greatly depends on one's experience which, as well as an improvement of climbing techniques, comes with age.

Keywords: sports performance, ice climbing, differences

INTRODUCTION

Ice climbing, as a climbing technique, has a very long history in traditional alpinism. The first ice climbing contest was organized in 1912. on Brenva glacier in Courmayeur, Italy. However, in the 2002 the first World Cup competitions under UIAA rules took place in Val Daone (Italy), Pitztal (Austria), Kirov (Russia), Quebec (Canada) and Saas Fee (Switzerland). In the meantime, many countries have held national competitions (UIAA, 2018.). In the past decade, we have been witnessing the flourishing of competitive ice climbing; the best proof of this is the fact that more and more competitions are organized every year. In addition, these competitions are constantly attracting more people who are interested in this sport or are professional athletes who are already competing.

Competitive ice climbing has two disciplines, lead and speed. In both categories ice climbers uses ice tools and crampons for progression. In speed, there are no technical difficulties; the goal is to climb 15-20m high ice wall as fast as possible. Lead climbing has time limitation and the goal is to reach the highest point of a technically demanding route (overhang, ceiling, candles).

For success in ice climbing beside strength and endurance of upper limb, flexibility of all joints has very important role. There are two typical ice climbing movements, "figure fours" and "figure nines" that illustrate this on the best way. These figures are useful for quickly moving into another reach without resetting body. The easiest way to go into a "figure four" is by sticking both tools into ice or rock, then one has to hike both feet up and drop one leg over the opposite hand (left leg over right hand, for example). After this, the climber has to tighten his abs and suck weight over his wrist. "Figure nines" are done in the same way as figure fours, but imply using the hand and leg from the same part of the body (Will, 2006). During these and many others movement climber's hands suffer the maximal load for period often longer than seven minutes. On other hand hip flexibility is also very important not only in those two figures but also in moves like "bridging" and "high steeping". All of this leads to the suggestion that increasing strength, endurance and flexibility may be beneficial.

Despite significant progress in ice climbing, there are still no scientific data that strictly refer to these athletes. The previous works were related to the injuries of ice climbers (Mashakovkiy et al.,2011; Schoffl et al., 2009; Schoffl et al., 2010.) and anthropometry of alpinists, rock/sport climbers (Arazi et al., 2017; Baker 1980; Giles et al., 2006; Grant et al., 1996; Morrison & Schoffl 2007;Watts el al., 1993;Puletić & Stanković 2014; Sheel 2004; Watts et al., 2003; Mermier et al., 2000) .

The objectives of this paper are determined the anthropometry, strength, endurance and flexibility of elite male ice climbers (IC) and to compare with non climbing (NC) athletes. In comparison of these two groups, we want to extract variables which are specific for ice climbing and realize how they affect the competitive placement. Also, we hope that knowledge from this work will contribute to improving the already existing and creating new training and nutritional protocols, as well as the selection patterns for young athletes.

METHODS

Participants

A total of 57 male aged 25.35 ± 4.74 years volunteered as subjects in the study. 34 of them competed at the Ice Climbing World Cup 2010 organized by UIAA in Saas Fee (Switzerland). They attended testing one day prior to the start of the competition. Later on, we excluded from this group 11 climbers who did not pass to the finals, so the number of ice climber was 23. The other group consisted of 23 athletes of same age but from different non climbing sports, such as: rowing, fitness, handball, hockey, basketball, water polo, karate and cycling.

Procedures

The subjects were instructed to rest well one day before the testing. Immediately before testing subjects were instructed to warm up. The design of the test battery was such that the pre-measuring did not affect the following measurements. The subjects were allowed to rest shortly between tests; the rest involved walking to the following testing location or an explanation of the following test. The schedule of the most demanding tests, such as strength and endurance, provided the subjects with enough time to rest in between. Rest periods between handgrip tests (different hands) lasted 45 seconds, while the rest periods for tests performed on the same limb lasted 90 seconds (Watts et al., 2003; Booth et al., 1999) . All participants had the same testing sequence. The tests described below are listed in the same order in which they were performed:

1. Height

All subjects were measured while in upright position with their back against the wall, barefoot and with the head in Frankfurt position. Measurement was done to the nearest 0.1cm using stadiometer Seca.

2. Arm span

Arm span was measured in the standing position with arms abducted horizontally. The greatest tip to tip distance between extended fingers was recorded in centimeters(Wilmore & Costill 1999.) The ratio of arm span to height, ape index, was calculated as arm span divided by height (Wilmore & Costill 1999; Winter et al., 2007).

3. Leg length

The subjects are in supine position with their legs flat on the mat. With their feet shoulder width apart, the length of a subject's right leg was measured from the anterior superior iliac spine to the apex of the medial malleolus and, with the foot plantar flexed as much as possible, the measurement extended to the tip of the big toe (Watts et al., 2003; Booth et al., 1999.). Measurement was performed with anthropometric meter to the nearest 0.5cm.

4. Body composition

The subjects were measured using Bioimpedance scale Tanita BC 418 MA in upright position with electrodes on their hands and under their feet. They have been measured in athletic mode, on room temperature and with dry hands and feet. Tanita's body resistance calculation involves: body fat mass and %, segmental body fat mass and % (left, right arm and foot, trunk), basal metabolic rate (BMR), fat free mass (FFM), segmental FFM (left, right hand and foot, trunk), total body water (TBW), body mass index (BMI) and body mass. Measurement was done to the nearest 0.1 kg for body mass, fat mass, FFM and TBW, 0.1% for fat % , 1kcal – BMR and 0.1kg/m2 – BMI.

5. Foot raise

A subject was required to stand facing a wall with his toes touching a line positioned 23cm from the wall. Both of the subject's hands have to be placed on the wall at shoulder height. Standing on his left foot, the subject was instructed to place the toe of his right foot as high up the wall as possible without allowing it to move laterally(Watts et al., 2003; Booth et al., 1999). The height the subjects raised their foot to was measured with a wall meter to the nearest 0.5 cm. Measurements were only taken for the right leg (Watts et al., 2003; Booth et al., 1999)

6. Hip flexion

Subjects are in the supine position with their legs flat on the mat and with their feet shoulder width apart. Their arms were bent in elbows and shoulders and their hands were positioned under the head. The subjects were instructed to lift their left foot by flexing their hip as much as possible, while avoiding flexing legs in knees or moving their right leg. The center of the goniometer body was placed over the greater trochanter, while Achilles' tendon was used for measuring the angle. Each subject underwent three trials and the best results were taken as final(Winter et al.,200). Measurement was taken from wall goniometer to the nearest 1°.

7. Hip abduction

The subjects are in the same position as the one they have to take for hip flexion, but this time with simphisis pubis positioned at dead center of the floor goniometer. Subjects were instructed to perform the best abduction of left leg they can, while their right leg remained in the initial position and with the knee stretched. Each subject underwent three trials and the best results were taken as final (Winter et al.,2007.); measurement was done to the nearest 1°.

8. Handgrip strength

A handgrip electronic dynamometer (Uno-Lux NS) was used for measuring grip strength. It was adjusted so that the grip was 4.5cm wide. The subjects stood upright with their feet slightly apart and elbows bent at a 90-degree angle. The subjects were instructed to squeeze the dynamometer gradually and with maximal force for at least 2s without moving the arm. One practice trial was followed by two tests on both hands(Booth et al., 1999;,Watts et al., 2003). Measurements were read from a monitor and were taken alternately between the left and the right hand. The best score for each hand was taken as the final result, and the measurement was done to the nearest 0.01N.

9. Handgrip endurance

After a 2-minute rest period, the subjects were instructed to grip and hold cross bars of electronic dynamometer, in the same way they did when measuring hand strength, but this time they had to hold on to the bars for as long as they can. During the test, a subject was provided with an opportunity to follow his progress on a monitor in real time. Besides the time and the endurance indicators, the monitor also displayed two lines showing 60% and 70% of maximal handgrip strength, in order for the subjects to be aware of the force they need to use during testing. Time was measured only for force exceeding 70%; when the force drops under 60% the time counter stops. Measurement was done only on one's dominant hand and with 2-minute rests between two attempts. The measurement was done to the nearest 0.01N.

10. Pincer strength

After a 2-minute break, just as in the case of the handgrip strength test, a subject has to grip cross bars of electronic dynamometer between his thumb and forefinger, while the other three fingers were not be used in this test. The subject was instructed to grip the dynamometer with his thumb and forefinger and squeeze with maximum strength for 2 seconds (Watts et al., 2003; Booth et al., 1999). Best of the two results was taken as the final result; the subjects were allowed to take 2-minute rests between two attempts. Measurement was done only for dominant hand and to the nearest 0.01N.

11. Static endurance of arm and shoulder muscles

A subject stands with his back to the wall; his pelvis, back and head have to be touching the wall. The feet are slightly separated and distanced from the wall by the length of the subject's foot. Knees are stretched. The subject lifts 5kg weights with an overhand grip, pulls them to his chest and extends his arms at shoulder height straight in front of himself. When the subject is no longer able to hold the position and starts to bend his arms or legs, the test is finished and he is instructed to separate his pelvis, back and head from the wall. The test is also finished if he allows one of his arms to drop more than 5cm, even if he is able to lift it again. This test is performed two times and the better of two results is taken the final result.

Ape index is calculated by dividing the arm span with one's body height, while SMR is calculated by dividing one's maximal hand grip strength with his body mass.

Statistical analysis

All statistical analyses were performed using SPSS software. Descriptive statistics included the measured mean (Mean), standard deviation (SD), median and range (minimum-maximum) for all variables. The differences between different groups were tested with analysis of variance test (ANOVA test). The level of statistical significance was set at level of $p<0.05$.

RESULTS

Mean age of ice climbers equaled 26.7±5.9 and non climbers 23.8±2.6 years, without any significant differences between groups. All ice climbers in group passed the qualification rounds for the Ice Climbing World Cup, while the control group was made up of non-climbers included athletes from different sports, who trained 10±3.9 hours per week on average over the past 11±3.5 years.

Table 1 presents means (standard deviation SD), median and range (Min-Max) for anthropometric variables of two groups. Significant differences between ice climbers and sport climbers are indicated.

When it comes to ranking at competitions, the most important factors are: age (older athletes achieve better results than younger ones), handgrip endurance, SMR, foot rise, hip abduction ($p<0.05$) and handgrip strength (left and right) ($p<0.01$).

Table 1. Anthropometric characteristics of two groups

Variable	Ice Climbers (n=23)			Non Cimbers (n=23)		
	Mean (SD)	**Median**	**Range**	**Mean (SD)**	**Median**	**Range**
Height (cm)	176.17 (7.4)*	175	172-204	181.6 (5.6)	184	164-191
Arm span (cm)	184.8 (8)	184	172-204	186.8 (5.7)	187	177-197.5
Ape index	1.05 (0.03)*	1.04	1.01-1.15	1.03 (0.03)	1.03	0.98-1.11
Length-LL (cm)	95.4 (4)	95	90-107	96.5 (3.7)	97	90-103
Length to thumb-LL (cm)	115 (3.3)	115	111-123	116.5 (4.3)	117	107-123
Mass (kg)	70.4 (7)*	69.7	61.1-92	80.9 (6.6)	82.50	65.8-95.9
BMI	22.7 (1.4)*	22.3	20-25.6	24.6(2.6)	24.7	20.8-29.8
BMR (kcal)	1855.3* (197.7)	1828	1615-2441	2078 (160.6)	2095	1772-2349
Fat (kg)	6.6 (2.1)*	6.6	2.7-11.9	10.7 (3.5)	10.4	5.7-17.7
Fat%	9.4 (2.9)*	9.2	3.9-15.4	13.1 (3.8)	13.10	7-21.40
Fat%-RL	10.3 (2.1)*	10.1	6.1-14.2	12.9(2.8)	12.70	8.5-17.7
Fat%-LL	10.2 (2.4)*	9.8	5.7-14.2	13.4 (2.8)	13.20	3.30-17.80
Fat%-RA	6.6 (2.1)*	6.6	2.3-10.1	10.09 (3.6)	12.30	4.70-15.50
Fat%-LA	6.6 (2.6)*	6.6	1.6-11.8	11.2 (3.8)	12.5	5-16.2
Fat%-T	9.5 (3.9)*	9.4	3.0-17.2	13.7 (5.1)	13.40	5.9-25.2
FFM (kg)	63.8 (6.7)*	62.7	55.7-84.0	70.2 (5.7)	70.7	59.40.-79.6
TBW (kg)	46.7 (4.9)*	45.9	40.8-61.5	51.4(4.2)	51.8	43.5-58.3

BMI – body mass index, BMR – basal metabolic rate, RL/A – right leg/arm, LL/A – left leg/arm, T – trunk, FFM – fat free mass, TBW – total body water, LL-leg length, * Statisticaly significant different from non climbers($p<0.05$)

There is no significant difference between ice climbers and non climbers in variables such as arm span, length-LL, length to thumb-LL. There is statistically significant difference between two groups in height, weight, BMI, BMR and all other segmental analysis.

Table 2 presents means (standard deviation SD), median and range (min-max) for variables foot rise, hip flexion, hip abduction, handgrip strength, handgrip endurance, pincer strength, strength to mass ratio, static endurance of arm and shoulder muscle.

Table 2. shows that ice climbers have significant less result for handgrip strength test in both hands, as well as better results of handgrip endurance of dominant hand. Considering results of the test hip abduction and shoulder muscle endurance (SME), ice climbers shows significant better flexibility and weaker endurance, comparing to non climbers.

All other measurements of muscular strength, endurance and flexibility (pincer, foot rise, hip flexion) didn't show difference between ice climbers and non climbers.

Table 2. Strength, endurance and flexibility characteristics of two groups

Variable	Ice Climbers (n=23)			Non Cimbers (n=23)		
	Mean (SD)	Median	Range	Mean (SD)	Median	Range
Foot rise (cm)	68.1 (5.7)	68	58-78	68.9(5.6)	58	60-79
Hip flexion(°)	94.5 (9.8)	90	72-112	95.6(9.6)	95	74-112
Hip abduction(°)	90.9 (9.8)*	90	72-112	81.6(7.9)	82	64-98
HG-LH(N)	442.2 (95.96)*	440.47	262.92-623.70	515.50(77.94)	526.63	354.77-639.48
HG-RH (N)	495.4 (95.55)*	516.8	316.27-714.87	516.6(69.87)	555.89	325.37-656.51
HG E(70%)-d (s)	30.3 (12.0)*	31.2	10.3-54.3	25.5(9.9)	27.3	8.7-48.6
Pd (N)	97.4 (25.0)	93.34	55.72-141.69	98.5(16.8)	96.14	72.50-140.03
SMR-d (N/kg)	7.05 (1.08)	6.96	5.13-9.60	7(1)	6.96	5.24-8.99
SME (s)	51.84 (20.04)*	48	7-91	64.9(10.07)	65	48-90

HG – handgrip, d – dominant hand, LH – left hand, RH– right hand, P – pincer strength, SMR – strength to mass ratio, HGE – handgrip endurance, SME – shoulder muscle endurance,*Statisticaly significant different from non climbers(p <0.05)

DISCUSSION

Over the past twenty years competitive ice climbing experienced an increase in popularity, while the existing climbing standards greatly improved. The Ice Climbing World Cup was organized every year over the past 15 years and each time it was bigger and more popular than the year before.

Results showed differences between anthropometric characteristics of elite ice climbers and non climbers; namely, climbers have a lower height, mass, body fat % and BMI. Similar results were obtained in studies about rock climbers. These studies describe sport climbers as athletes with small to moderate height and with very low % of fat(Giles et al.,2006; Grant et al.,2001; Watts et al.,1993; Watts et al., 2003). Differences between groups regarding body fat percentage have been presented in all five segmental measurements ($p<0.05$). Based on our research and other studies from this field, we could deduce that a higher percentage of body fat has a negative impact on performance and ranking in a sport which implies lifting one's weight against the force of gravity.

BMR was significantly lower in ice climbers ($p<0.05$). There was no significant difference in age between the two groups, which lead us to believe that low values of BMR are consequences of low stature and body mass.

The battery of hip flexibility tests includes two direct and one indirect measurement method. For this purpose, we used foot rise as an example for the indirect method, while hip flexibility corresponds to the direct method. Both of them show no differences between groups, but each indicates that ice climbers who can perform a better foot rise or have better hip flexibility have higher competitive ranking ($p<0.05$). On the other hand, hip abduction as the second direct method, measured with goniometer, shows significant difference ($p<0.05$) between the two groups and greatly affects ice climbers ranking on competitions. This may indicate the importance of flexibility in competition.

Ice climbers possess less handgrip strength in both hands when compared to the non climbers, but hand grip shows its positive influence on competition ranking. These findings indicate that ice climbers should develop handgrip strength in order to be ranked higher in the competition.

During ice climbing, forearm muscle often produced maximal or submaximal force with periods of rest in between trials. In the case of the handgrip endurance test, we measured time for strength exceeding 70% of previously measured maximal handgrip strength for the dominant hand. The previous papers (Booth et al.,1999, Watts, 2004; Humphreys & Lind 1963) implied that a grip strength exceeding 70% of maximal force closes all the blood vessels and prompts anaerobic activity of muscles. In this test ice climbers show statistically better results in comparison to the non climbing group. These measurements indicated that climbers with better anaerobic capacity have better ranking during competition ($p<0.05$).

A measurements characteristic of climbers was pincer strength; it was measured with electric dynamometer. During ice climbing, climbers used tools which have ergonomic shape and resting hooks. The first hook is placed at the bottom, while the second one is placed at 1/3 of handhold height. The second one is often used by climbers in the following way: the index finger is put over it for rest or better grip. Consequently, this test is particularly interesting if we want to determine and compare muscle tension in index finger of ice climbers and non climbers. In this test we did not find any statistically important difference between groups. In addition, pincer strength testing does not seem to have any influence on competitive ranking.

Testing for shoulder muscle endurance can make a significant contribution in an attempt to determine anaerobic capacity of bigger muscle groups. Ice climbers had less endurance, comparing to non climbing athletes. Although this testing does not influences competitive ranking, and it may not be specific enough for climbers.

There was no significant difference in age between the groups. The age factor was proven to be extremely important for ice climbers – older athletes have better competitive placement ($p<0.05$).

CONCLUSION

In our study, we found that elite ice climbers have moderate body composition with low body fat percentage, good hip flexibility, and excellent handgrip endurance. On the other side, ice climbers need to know that except endurance, strength and flexibility success at competitions greatly depends on one's experience which, as well as an improvement of climbing techniques, comes with age. Some test showed up as non specific for ice climbers and not relevant to competitive result (shoulder muscle endurance, pincer strength) so future researchers should think about excluding them from battery test.

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THE INFLUENCE OF ISOMETRIC MUSCLE FORCE CHARACTERISTICS ON SWIMMING RESULTS

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SUMMARY

The aim of this research was to determine the influence of muscle force on swimming results. Thirteen male frestyle swimmers (Age=16.9±1.5 yrs; Height=179.1±6.9 cm; Weight=68.4±9.0kg; FINA Points Scoring 2017 – 50 and 100 m freestyle long course = 572.0 ± 80.8; n = 13) performed an upper (hand grip), lower body (half-squat) and lower back (dead-lift) isometric muscle test. The sample of variable system included eight variables for the estimation of muscle concractile potential of knee extensor (EK_Fmax, EK_FmaxREL), the extensor of lower back muscle (EL_Fmax, EL_FmaxREL) and muscle potential of dominant hand grip (SD_Fmax, SD_FmaxREL), while for the estimation of the swimming results at 50 and 100 meters free, one variable was used (FINA points 2017). For the measurement of maximum muscle force of back extensors and knee extensor a Japanese digital force measuring device „IMADA“ 32X-1100 with the software program WinWedge 3.4 was used. For the measurement of dominant hand grip maximum force PAT2 (Physical Ability Test) device was used. The swimming results was presented in FINA points 2017. The data obtained by this research were processed by the statistics package „SPSS 19“. For all the variables, the descriptive statistics and the regression analyses were used in order to determine the influence of muscle force to the swimming results. The results of regression analyses showed the significant statistical influence of the muscle force on swimming results (the muscle potential of the knee extensors, F= 5.454, **p= 0.025**; the muscle potential of back extensors F= 4.740, **p= 0.036** and the muscle potential of hand grip, F= 5.526, **p= 0.024**). The obtained results indicate that the swimming results at 50 and 100 meters free directly depends on the variables who represent upper body, lower body and lower back muscle potential, respectively.

Keywords: Isometrics force, hand grip, dead-lift, half-squat, swimming

INTRODUCTION

The main task in competitive swimming is to take the shortest possible time to complete the determined distance. For example, on competitions in long distance events swimming technique and tactics are main factors for good results (Maglischo, 2003). On the other hand, in competitive sprint events muscle power and force is very important since very high speeds are reached (Stager and Coyle, 2005; Beretić et al., 2013). In sports, muscle force measurement is performed in static (isometric) and dynamic conditions. In isometric conditions, the muscular force is measured by the method of dynamometry (Dopsaj, 2010; Dopsaj et al., 2010). Therefore, in sprint events muscle power and force contractile abilities must be very high to overcome the water resistance and drag (Dominguez-Castells et al., 2013; Trinity et al., 2006). The aforementioned muscle force and power that each swimmer has to achieve to be fast may be exerted by arms and/or legs, and its estimate may be of great interest for training plans. In the general population, and in elite sports, the contractile caracteristics of hand grip is used as an important parameter in the assessment of physical fitnes of the upper body muscle potential (Demura et al., 2003; Markovic & Jaric, 2004; Dopsaj et al., 2010; Dopsaj et al., 2009; Svantesson et al., 2009; Ivanovic et al., 2009). Direct muscle force measurement during swimming is difficult and challenging, although significant advances have been made in swimmer's technology (Akis and Orcan, 2004). In spite of that, the dynamometry can be found for the purpose of measuring the muscle contractile characteristics of the hand grip relative to the total body strength. The characteristics of the hand grip can be relatively predicted because they are directly related to the morphological structure, fitness, health and physiologically conditions at the time of testing (Taglione et al., 1999). Also, the lower body muscle potential have an important role in swimming. The contractile abilities of the lower body muscle potential can significantly affect the efficacy of the swimming start, it is assumed that the higher values of the muscles contractile characteristics of the lower body, this will make the starting ability better and final results, respectively (Beretić et al., 2013). In the context of the above, it seems that their contribution is different, since the acceleration of leg kick is usually considered a factor of less importance for the arm propulsion of a freestyle (Hollander et al., 1987).

METHODS

Subjects

The sample of participants was 13 active male swimmers (Age = 16.9 ± 1.5 yrs; Height = 179.1 ± 6.9 cm; Weight = 68.4 ± 9.0 kg; FINA Points Scoring 2017 – 50 and 100 m freestyle long course = 572.0 ± 80.8) with at least four years of competitive experience, members of the swimming club "Nis 2005" from Nis. All methods and procedures of this investigation were approved by the ethical committee of the University of Niš, Faculty of Sport and Physical Education, Serbia, and they conformed to the Code of Ethics of the World Medical Association (Declaration of Helsinki).

Procedure

All of the tests were performed on the same day. The tests for muscle potential characteristics were performed in the morning, while the swimming results were used from official results (www.swimrankings.net).

To evaluate the contractile abilities of the muscles potentials three tests where used: The isometric test of the dominant arm hand grip (SD_Fmax, SD_FmaxREL), isometric standing back extension test (EL_Fmax,EL_FmaxREL) and isometric standing legs extension test (EK_Fmax,EK_FmaxREL).

The Japanese digital IMADA Z2H-1100 with the WinWedge 3.4 software was used to measure the maximum muscle force of the back exstensors and muscle of the lower body exstensors. The value displayed on the digital meter is the absolute value of the maximum force. When the absolute value of the force is divided by the weight of the participants, the relative force value is obtained.

For the isometric standing back extension test the participant occupies a standing position on the stand with feet separated in the width of the hips. The body of the participant is slightly bent. With the straight arms, the subject holds the digital force gauge in front of you. The chain that connects the digital force meter with the stand is fully taut. Respondent from the initial position pulls the dynamometer evenly with the strength of the muscle of the posterior-lumbar muscle extensors, rectifying in the shoulder and upper part of the chest, where the arms are straight. The result is expressed in newton (N). The test description was taken from Dopsaj, 2010.

For the isometric standing legs extension the participants holds a dynamometer behind and under the back, where the knees are in a mild flexion and the feet are spaced apart in the width of the hips. The chain connecting the stand with the digital power march is fully taut. Participant from the initial position pulls a dynamometer with uniformly extended arms by the force of the lower body muscles. The result is expressed in newton (N). The test description was taken from Dopsaj, 2010.

To measure the maximum force of the hand grip, a PAT2 (Physical Ability Test) device was used, based on the contractile characteristics of the dominant arm.The participant takes a sitting position with an outstretched hand laterally next to the body that holds the construction with a tensiometric dynamometer. The participant performs the isometric contraction of the fingers of the maximum intensity with the task of closing the ends of the construction probe, whereby the body position is same as well as at the beginning of the test. The test description was taken from Dopsaj, 2006.

Statistical analysis

Means and standard deviations were calculated for each variable. A regression analysis was used to determine the influence of the overall muscle force variables on the swimming results, where the following statistical parameters were calculated: Unstd. Beta = Unstandardized regression coefficients values, Beta = Standardized regression coefficients values, t = Standardized regression coefficients significance tests, p = Standardized regression coefficients level of significance, R= Multiple correlation coefficient, R2 adjust = Adjusted determination coefficient, Std. Err. Est. = Standard error of the estimate, F = Multiple regression analysis significance tests, p = Multiple correlation level of significance.

RESULTS

Table 1. Descriptive statistics

Varijables	**n**	**Mean**	**Std. Deviation**	**CV**	**p**
Age	13	16.85	1.46	9%	0.512
Height	13	179.08	6.87	4%	0.369
Weight	13	68.64	9.04	13%	0.938
FINA 2017	13	572.00	80.80	14%	0.991
EK_Fmax	13	1251.46	245.12	20%	0.576
EK_FmaxREL	13	18.23	2.47	14%	0.994
EL_Fmax	13	1314.77	212.15	16%	0.998
EL_FmaxREL	13	19.17	1.89	10%	0.993
SD_Fmax	13	389.31	55.84	14%	0.902
SD_FmaxREL	13	5.70	0.69	12%	0.887

Legend: **n** – number of participants, **Mean** - mean, **Std. Dev** - standard deviation, **CV** - coefficient of variation, **p** – K-S test

Table 2. Regression analysis of swimming results with isometric concractile muscle potential of knee extensor in male swimmers (n=13).

Variables	**Unstd. Beta**	**Beta**	**t**	**p**	**R**	**R^2_{adjust}**	**Std. Err. Est.**	**F**	**p**
EK_Fmax	0.349	1.057	3.200	**0.009**	0.722	.426	61.212	5.454	**0.025**
EL_FmaxREL	-24.228	-.566	-2.025	0.070					

Legend: **EK_Fmax** = knee extensor maximal muscle force, **EK_FmaxREL** = knee extensor relative muscle force, **Unstd.Beta** = Unstandardized regression coefficients values, **Beta** = Standardized regression coefficients values, **t** = Standardized regression coefficients significance tests, **p** = Standardized regression coefficients level of significance, **R**= Multiple correlation coefficient, **R^2 adjust** = Adjusted determination coefficient, **Std. Err. Est**. = Standard error of the estimate, **F**= Multiple regression analysis significance tests, **p** = Multiple correlation level of significance.

Table 3. Regression analysis of swimming results with isometric concractile muscle potential of back extensor in male swimmers (n=13).

Variables	**Unstd. Beta**	**Beta**	**t**	**p**	**R**	**R^2_{adjust}**	**Std. Err. Est.**	**F**	**p**
EL_Fmax	0.326	0.856	3.066	**0.012**	0.698	0.384	63.417	4.740	**0.036**
EL_FmaxREL	-24.228	-0.566	-2.025	0.070					

Legend: **EL_Fmax** = back extensor maximal muscle force, **EL_FmaxREL** = back extensor relative muscle force, **Unstd.Beta** = Unstandardized regression coefficients values, **Beta** = Standardized regression coefficients values, **t** = Standardized regression coefficients significance tests, **p** = Standardized regression coefficients level of significance, **R**= Multiple correlation coefficient, **R^2 adjust** = Adjusted determination coefficient, **Std. Err. Est**. = Standard error of the estimate, **F**= Multiple regression analysis significance tests, **p** = Multiple correlation level of significance.

Table 4. Regression analysis of swimming results with isometric concractile muscle potential of dominant hand grip in male swimmers (n=13).

Variables	**Unstd. Beta**	**Beta**	**t**	**p**	**R**	**R^2_{adjust}**	**Std. Err. Est.**	**F**	**p**
SD_Fmax	1.271	.878	3.304	**0.008**	0.725	0.430	61.002	5.526	**0.024**
SD_FmaxREL	-68.832	-.584	-2.195	**0.053**					

Legend: **SD_Fmax** = dominant hand grip maximal muscle force, **SD_FmaxREL** = dominant hand grip relative muscle force, **Unstd.Beta** = Unstandardized regression coefficients values, **Beta** = Standardized regression coefficients values, **t** = Standardized regression coefficients significance tests, **p** = Standardized regression coefficients level of significance, **R**= Multiple correlation coefficient, **R^2 adjust** = Adjusted determination coefficient, **Std. Err. Est**. = Standard error of the estimate, **F**= Multiple regression analysis significance tests, **p** = Multiple correlation level of significance.

Table 1. shows results for the descriptive statistic of all applied variables. Table 2. shows the results of regression analysis of swimming results with isometric concractile muscle potential of knee extensor in male swimmers. Results are indicating that there is statistically significant influence of the knee extensor muscle potetntial onto swimming result (**p=0.025**). This is also confirmed by high values of multiple correlation coefficient (R=0.722) and determination coefficient (R^2=0.426). Individually, out of each applied variables, the statistically relevant influence onto the swimming results has the variable **EK_Fmax** (**p=0.09**). Regression analysis results in Table 3. shows statistically significant influence of the whole system of lower back extensor variables for evaluation muscle potential onto the swimming result (**p= 0.036**). The high values of multiple correlation coefficient (R=0.698) and determination coefficient (R^2=0.384) is also confirmed. Individually, out of each applied lower back extensor muscle, the statistically relevant influence onto the swimming results has variable **EL_Fmax** (**p=0.012**). Table 4. shows the results of regression analysis of swimming results with isometric hand grip concractile muscle potential of dominant arm in male swimmers. There is statistically significant influence of the hand grip muscle potetntial onto swimming result (**p= 0.024**). This is also confirmed by high values of multiple correlation coefficient (R=0.725) and determination coefficient (R^2=0.430). Individually, out of each applied variables, the statistically relevant influence onto the swimming results has both variables **SD_Fmax** (p=0.08) and **SD_FmaxREL** (p=0.53).

DISCUSSION AND CONCLUSION

The aim of this study was to determine the influance of the muscle contractile potential of the leg extensor muscles, lower back exstensor muscles, hand exstensor muscles and to determine whether the level of maximum and relative muscle force (Fmax and FmaxREL) are influence on swimming results. The obtained results indicate that there is statistically significant influance of all maximal muscle force variables on swimming. Relative values of hand exstensor muscles maximum force (SD_FmaxREL) also showed significant influence on swimming results. In a study of Garrido et al. (2012) obtained results indicate that there is statistically significant association of maximal muscle force of the upper body muscles with swimming results that is in accordance with the obtained results of the conducted research. Study of Dopsaj et al. (2011), which examined the contractile characteristics of the hand exstensor muscles in the function of assessing the level of development of physical abilities, it has been proved that using the method of mathematical modeling, the measurement area is described by a percision at the prediction level of 99.99%. The results show that the average value of the students right-hand of the Criminal Police Academy was 599.19±52.33 N whereas in the conducted survey of swimmers the average value was 389.31±55.84 Geladas et al. (2005) examined the correlation between anthropometric characteristics and muscle potential with a 100 m freestyle swimming results. The results indicate a statistically significant correlation of the maximum muscle force of the hand exstensor and the swimming results (r=-0.73); the negative sign indicates that the higher values of the muscle force of the are associated with better results in the 100 meter freestyle. Research of Crowley et al. (2018) studied the most common dryland training exercises for elite swimmers to improve physical fitness and concluded that dead lift, which is fifth in usefulness from possible 25 exercises, has a significant impact on swimming performance, which is in line with the conducted research. Observing the obtained results of the conducted research, it can be concluded that the greatest statistically significant influence on swimming speed has the muscle potential of the hand exstensor (F=5.526, p=0.024), a somewhat smaller statistically significant influence of the muscle potential of the knee extensions (F=5.454, p=0.025) and the lowest statistically significant influance has the muscle potential of lower back extensor (F=4.740, p=0.036). These results are in line with the results of Magel (1970), which have shown that the muscle potential of the upper body statistically significantly affects the swimming results. The outcomes of this study show that muscle force contractile potentials obtained by performing the simple isometric muscle force tests measured on land do relate to swimming performance and can be used by swimmers and coaches to improve their plans and programs.

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SPECIFIC COORDINATION IN FEMALE RHYTHMIC GYMNASTS OF DIFFERENT COMPETITION PROGRAM

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SUMMARY

The main objective of this study was to examine the specific coordination in female rhythmic gymnasts (RGs) competing in different programs, as well as to determine possible differences between them within each age group category. The sample consisted of 91 national- and international-level female RGs, distributed in five age group categories (15 seniors, aged 16 years and older; 25 juniors, aged 14-16 years; 17 advanced, aged 12-14 years; 20 intermediate, aged 9-12 years; 14 beginners, aged six to nine years) and two competition programs ("A" program, N=42; "B" program, N=49). Their baseline characteristics (age, body height, body mass, body mass index, years of training experience) were established, as well as the level of their specific coordination (B-ROL- ball rolling over the arms, R-TCJ- throwing, catching and jumping through a rope, H-SKP- skipping through a hoop, and C-JUG- clubs juggling). By means of t-test for independent samples, statistically significant differences in specific coordination of "A" and "B" juniors (B-ROL: p=0.044) and advanced-level gymnasts (B-ROL: p=0.049, R-TCJ: p=0.022 and C-JUG: p=0.019) were established. The differences at multivariate level (Discriminant canonical analysis) were missing.

Keywords: rhythmic gymnastics, motor coordination, differences, age group categories

INTRODUCTION

Talent identification in sport is a scientific process which represents a complex network of many interdependent influences, and the key is to start with reliable measures that correlate with sports performance, such as morphological characteristics and motor abilities. Motor abilities have an important place in the performance of complex forms of movement and they are precondition for sports tasks solving. These abilities are mostly genetically determined, but by the long-term systematic training they can be improved and perfected, but only to genetically predicted limits (Moskovljević, 2013).

Every single sport requires the development of certain motor skills, and then we are talking about specific motor abilities- the motor skills that are acquired during life span and are the result of specific training in certain sport. Rhythmic Gymnastics (RG) is a competitive discipline, a sport that combines German accent on apparatus handling, the Swedish approach to free exercises, with elements of classical ballet. It is a blend of gymnastics, dance and apparatus handling, a combination of impressive motor structures that are characterized by beauty, elegance and harmony of movement, with the constant striving to achieve perfectly coordinated, coherently connected and precisely executed motions and movements (Ivančević, 1976, 33) by individuals or group of five, with the use of clubs, hoop, ball, ribbon or rope. This artistic and aesthetic specialized discipline requires a well-prepared and trained body, which can meet the high demands of the training process (Douda, Avloniti, Kasabalis, & Tokmakidis, 2007): very young athletes, early specialization before bone maturation, a large training volume, many hours of intensive training per week, a lot of repetitions, a high level of technical elements performance. All of this requires a variety of motor abilities and skills, given the high level of physical and psychological stress, both in training and in competitions (Bobo-Arce & Méndez-Rial, 2013). Thus, the complexity of execution in RG is conditioned by displaying of optimal motor abilities, such as maximal flexibility, a good kinesthetic sense (balance maintaining), precision, speed reaction, explosive strength, coordination, sense of rhythm, musicality, perfect

RG-specific apparatus handling, and among them motor coordination is a highly stable talent indicator (Ahnert, Shneider, & Bös, 2009; di Cagno, Battaglia, Fiorilli, Piazza, Giombini et al., 2014). As a complex sport, RG requires increased space-time coordination between the body movement of RGs and apparatus handling, which makes specific coordination a vital part of RGs' technical preparation, with an important role in creating the necessary preconditions for learning as many RG techniques as possible (Purenović-Ivanović, Popović, Stanković, & Bubanj, 2016). In addition, RG has its specific physiological and biomechanical requirements, and these sports-specific requirements change with the level of skills, training load (i.e., frequency and intensity of training), and it usually increases with the level of competition.

Serbian Gymnastics Federation has formed three competition programs ("A", "B" and "C", i.e. high-, medium- and low-level program) which all differentiate in some competition rules, i.e. in items like: final score, the maximal number of body difficulties, scoring of body difficulties, age category classification, number of routines and type of apparatus, training hours per week, etc., and it is absolutely legitimate to assume that these different requirements in different competition programs could produce differences among them. As tribute to this assumption, there were some researches interested in comparing gymnasts of different performance level (di Cagno, Baldari, Battaglia, Brasili, Merni, Piazza, Toselli, Ventrella, & Guidetti, 2008; Broda & Poliszczuk, 2009; da Silva & Rocha, 2011; Purenović-Ivanović, Popović, Moskovljević, & Penčić, 2017), where dissimilarities in anthropometric and many other values between elite and low(er) profile gymnasts of the same age were recorded. The purpose of the current study was to examine and compare specific coordination of rhythmic gymnasts (RGs) of different competition programs, within each of five age group categories.

METHODS

Subjects

Ninety-one rhythmic gymnasts (RGs), between the ages of 7 and 20 years, voluntarily participated in the study (Mean±SD, age: 12.66±3.17 years, body height: 150.72±14.41 cm, body mass: 39.79±12.01 kg, BMI: 17.03±2.35 kg/m^2, sports experience: 6.42±2.73 years). All of the participants are individual competitors at national and/or international level in an "A" and "B" program (i.e. high- and medium-level competition program), distributed in five age group categories according to the official age classification of the Serbian Gymnastics Federation (see Table 1).

Table 1. Distribution of study participants according to age group category, competition program and country of competition

Age Group Categories	6th "Montenegro Cup 2013" (Budva, Montenegro)	2014 National Championships (Belgrade, Serbia)	TOTAL
Seniors	-	7A + 8B	7A + 8B = **15**
Juniors	1A + 5B	12A + 7B	13A + 12B = **25**
Advanced	2A + 6B	5A + 4B	7A + 10B = **17**
Intermediate	5A + 4B	4A + 7B	9A + 11B = **20**
Beginners	6A	8B	6A + 8B = **14**
TOTAL	**14A + 15B = 29**	**28A + 34B = 62**	**42A + 49B = 91**

Legend: A- "A" program (national- and international-level RGs competing according to FIG rules),
B- "B" program (national- and international-level RGs, but with less demands for difficulties compared to an "A" program gymnasts).

Procedure

The first part of the testing was conducted at the end of June 2013 in Budva (Montenegro), when 14 elite (i.e. "A" program competitors) and 15 international-level gymnasts (i.e. "B" program competitors) were tested. During the 2014 National Championships held in Belgrade (Serbia) on October 25th, the second testing included 28 top-level (i.e. "A" program competitors) and 34 national-level Serbian gymnasts (i.e. "B" program competitors). All testing was performed in accordance with the ethical standards of the Helsinki Declaration (WMA, 2002).

All the measurements were taken by the authors in optimal climatic conditions, with the participants in their underwear, and according to the methods proposed by the International Biological Programme (Weiner & Lourie, 1969).

The Martin anthropometer was used for obtaining the RGs' body height (in cm), while body mass (in kg) and body mass index (BMI, in kg/m^2) were assessed with a tetrapolar bioelectrical impedance device, Omron BF511 (Kyoto, Japan). For the estimation of RG-specific coordination skills the tests proposed by Jastrjembskaia and Titov (1999) were used: ball rolling over the arms (B-ROL, in the number of consecutive successful attempts), throwing, catching and jumping through a rope (R-TCJ, in the number of consecutive successful attempts), skipping through a hoop (H-SKP, in the number of consecutive successful attempts during 15 sec) and clubs juggling (C-JUG, in the number of consecutive successful attempts during 10 sec). Data on their age and years of sports experience were collected by interviewing the participants.

Statistical analysis

The data were analyzed using the Statistical Package for the Social Sciences, version 21.0 (IBM SPSS 21.0, SPSS Inc, Chicago, USA). Descriptive statistics [average value (Mean), Standard Deviation (SD), Range] were summarized for all variables. Normality was tested using the one-sample Kolmogorov-Smirnov test (K-S). A t-test for independent samples (t- t value, df- degrees of freedom, Sig.- statistical significance) so as Discriminant canonical analysis (Eigenvalue- coefficient of discrimination, Canonicl R- coefficient of canonical correlation, Wilk's Lambda- value of Bertlet's test, Chi-Sqr.- χ^2 test, df- degrees of freedom, p-value- level of statistical significance) were performed with the aim of determining the differences in RG-specific coordination skills between RGs of high and medium competition and training level. The level of significance was set at $p<0.05$.

RESULTS

The baseline characteristics of the "A" and "B" study participants, divided into five age group categories, are presented in Tables 2 and 3, respectively. In Tables 4 and 5 are descriptive statistics data of the measured specific coordination skills in "A" and "B" RGs of each age group category, and in Figures 1 and 2 according to the competition program also.

Table 2. Baseline characteristics of the **"A"** study participants

Age Group Categories	Variables	Age (yrs)	Body Height (cm)	Body Mass (kg)	BMI (kg/m^2)	Sports Experience (yrs)
"A" Seniors (n=7)	*Mean±SD*	17.56±1.66	165.9±8.17	57.1±6.0	20.73±1.49	10.71±1.98
	Range	16.22 – 20.34	154.4 – 178.2	51.4 – 67.0	19.0 – 23.3	9.0 – 14.0
	K-S (Sig.)	.470	.917	.884	.739	.831
"A" Juniors (n=13)	*Mean±SD*	14.52±0.73	162.24±8.24	48.81±7.22	18.43±1.61	8.39±1.5
	Range	13.3 – 15.82	146.1 – 176.7	31.0 – 62.7	14.5 – 20.4	5.0 – 10.0
	K-S (Sig.)	.907	.768	.787	.820	.416
"A" Advanced (n=7)	*Mean±SD*	12.04±0.5	150.44±6.14	35.46±4.0	15.59±0.66	6.14±1.46
	Range	11.38 – 12.63	142.2 – 157.5	30.2 – 40.5	14.5 – 16.3	4.0 – 8.0
	K-S (Sig.)	.839	.867	.993	.944	.588
"A" Intermediate (n=9)	*Mean±SD*	10.03±0.83	137.47±6.43	28.4±3.04	15.0±0.69	5.56±1.51
	Range	8.71 – 11.09	125.1 – 145.7	22.7 – 32.6	13.7 – 15.8	3.0 – 8.0
	K-S (Sig.)	.986	.921	.941	.766	.954
"A" Beginners (n=6)	*Mean±SD*	7.49±0.46	127.38±5.66	23.78±2.61†	14.62±0.42 ‡	2.58±0.92
	Range	7.04 – 8.11	123.3 – 138.5	21.2 – 28.7	13.9 – 15.0	1.5 – 4.0
	K-S (Sig.)	.952	.393	.528	.989	.887
Total "A" sample (N=42)	*Mean±SD*	12.65±3.38	150.59±15.71	40.02±13.1	17.06±2.52	6.96±2.91
	Range	7.04 – 20.34	123.3 – 178.2	21.2 – 67.0	13.7 – 23.3	1.5 – 14.0
	K-S (Sig.)	.932	.586	.357	.142	.635

Legend: "A"- "A" program, **n, N-** number of study participants, **Mean-** average value, **SD-** standard deviation, **K-S-** Kolmogorov-Smirnov test**, Sig.-** significance, **yrs-** years, **BMI-** Body Mass Index.
†‡ t-test ("A" vs. "B"): † p=0.012, ‡ p=0.002.

Based on the BMI cut-off points for girls of different ages (CDC, 2000), it can be stated that BMI value of most of the “A” RGs (n=40, i.e. 95.24%) is within the normal range, and only two of them (one junior and one beginner, i.e. 4.76%) are bellow the recommended BMI values. In the group of gymnasts competing in a “B” program, the situation is similar to those recorded in “A” RGs: all seniors, juniors and intermediate-level RGs have BMI in the range of the recommended values (n=40, i.e. 89.79%), and lower values were recorded only in three advanced-level RGs and two beginners. However, the results of t-test for independent samples indicated the statistically significant differences in body mass and BMI of the “A” and “B” gymnasts, but only in the group of beginners (p=0.012 and p=0.002, respectively). As for the normal distribution of data, there were no statistically significant variation in any of the five examined variables (see Tables 2 and 3).

Table 3. Baseline characteristics of the **“B”** study participants

Age Group Categories	Variables	Age (yrs)	Body Height (cm)	Body Mass (kg)	BMI (kg/m²)	Sports Experience (yrs)
“B” Seniors (n=8)	*Mean±SD*	17.49±1.17	163.39±5.73	54.11±3.54	20.26±0.82	7.94±2.18
	Range	16.16 – 19.76	150.0 – 169.0	47.4 – 58.7	19.1 – 21.4	5.0 – 11.0
	K-S (Sig.)	.698	.334	.994	.999	.896
“B” Juniors (n=12)	*Mean±SD*	14.54±0.79	163.7±5.75	48.39±5.08	18.01±1.17	7.58±1.56
	Range	13.31 – 15.59	153.2 – 173.9	40.0 – 57.8	16.4 – 19.8	4.0 – 9.0
	K-S (Sig.)	.955	.996	.969	.702	.526
“B” Advanced (n=10)	*Mean±SD*	11.98±0.9	148.93±10.15	36.68±8.01	16.34±1.89	5.7±2.16
	Range	10.76 – 13.8	136.0 – 161.5	25.5 – 48.0	13.8 – 19.1	1.0 – 9.0
	K-S (Sig.)	.998	.768	.999	.979	.923
“B” Intermediate (n=11)	*Mean±SD*	10.62±0.88	142.46±5.23	30.91±5.22	15.14±1.72	5.0±1.89
	Range	9.43 – 12.02	133.4 – 149.6	22.9 – 40.2	12.7 – 18.9	2.0 – 8.0
	K-S (Sig.)	.910	.999	1.0	.946	.164
“B” Beginners (n=8)	*Mean±SD*	8.69±0.28	132.8±4.22	27.56±2.14	15.6±0.51	3.19±1.85
	Range	8.27 – 9.08	127.9 – 139.3	24.3 – 30.8	14.5 – 16.0	1.0 – 6.0
	K-S (Sig.)	.962	.981	.998	.355	.510
Total “B” sample (N=49)	*Mean±SD*	12.66±3.02	150.82±13.37	39.61±11.13	16.99±2.23	5.96±2.49
	Range	8.27 – 19.76	127.9 – 173.9	22.9 – 58.7	12.7 – 21.4	1.0 – 11.0
	K-S (Sig.)	.802	.375	.316	.463	.084

Legend: “B”- “B” program, **n, N-** number of study participants, **Mean-** average value, **SD-** standard deviation, **K-S-** Kolmogorov-Smirnov test**, Sig.-** significance, **yrs-** years, **BMI-** Body Mass Index.

The Kolmogorov-Smirnov test showed no deviation from the normal distribution of specific coordination data in RGs of all age group categories (Table 4). According to the cut-off points of coordination rating scale (Jastrjembskaia & Titov, 1999, 140) the "A" seniors have achieved excellent results in every out of four applied RG-specific coordination tests, and especially in tests B-ROL and C-JUG (7 out of 7, i.e. 100%). More specifically, based on the average value of the coordination tests in this age group and program category, excellent results have been achieved in tests B-ROL, H-SKP and C-JUG, and good in test R-TCJ. The situation in the subsample of the "A" junior RGs is similar to the seniors’: excellent scores in tests B-ROL (12 out of 13, i.e. 92.3%), H-SKP (11 out of 13, i.e. 84.6%) and C-JUG (11 out of 13, i.e. 84.6%), but poor scores in R-TCJ test (38.5% had fair scores, 30.7% performed it well, 15.4% had poor scores and only 15.4% had excellent scores). The results of the "A" advanced-level RGs resemble to those recorded in juniors: excellent scores in tests B-ROL (5 out of 7, i.e. 71.4%), H-SKP (6 out of 7, i.e. 85.7%) and C-JUG (5 out of 7, i.e. 71.4%), but poor scores in R-TCJ test (excellent, good and fair scores were recorded in 28.6% for each of the named rating scales, and 14.3% had poor scores). The subsample of the "A" intermediate-level RGs achieved excellent results in the test H-SKP (8 out of 9, i.e. 88.9%); smaller percentage scored the excellent results in B-ROL test (4 out of 9, i.e. 44.4%); in case of C-JUG test the majority had good scores (5 out of 9, i.e. 55.6%), but there were also those with excellent results in this test (n=3, i.e. 33.3%), while 44.4% of the “A” intermediate-level RGs scored poorly in R-TCJ test. The “A” beginners were the most successful in test H-SKP (4 out of 6, i.e. 66.7%); in case of the C-JUG test, the highest percentage (50%, i.e. 3 out of 6) gain fair scores, while in case of the remaining two test (B-ROL and R-TCJ), the majority of beginners (4 out of 6, i.e. 66.7%) did not manage to do it at all (without a single successful attempt).

Table 4. Specific coordination in **“A”** RGs of different age group categories

Age Group Categories	Variables	B-ROL	R-TCJ	H-SKP	C-JUG
“A” Seniors (n=7)	*Mean±SD*	51.0±24.87	8.71±3.99	31.71±9.01	12.0±1.73
	Range	14 – 70	2 – 15	12 – 39	10 – 14
	K-S (Sig.)	.292	.804	.448	.993
“A” Juniors (n=13)	*Mean±SD*	42.85±20.62◊	4.77±2.46	30.15±6.04	10.92±3.01
	Range	7 – 70	2 – 9	17 – 39	3 – 16
	K-S (Sig.)	.913	.487	.990	.262
“A” Advanced (n=7)	*Mean±SD*	32.43±27.83**Δ**	6.14±3.67†	30.71±5.94	10.71±3.15•
	Range	0 – 75	1 – 11	19 – 36	7 – 15
	K-S (Sig.)	.923	.992	.956	.990
“A” Intermediate (n=9)	*Mean±SD*	13.44±11.27	2.11±1.83	31.33±4.69	6.78±3.23
	Range	1 – 40	0 – 6	21 – 37	0 – 11
	K-S (Sig.)	.673	.853	.871	.853
“A” Beginners (n=6)	*Mean±SD*	0.33±0.52	0.33±0.52	23.17±9.45	4.17±4.62
	Range	0 – 1	0 – 1	6 – 31	0 – 13
	K-S (Sig.)	.272	.272	.869	.463
Total “A” sample (N=42)	*Mean±SD*	30.10±25.89‡	4.45±3.75	29.76±7.12	9.21±4.11
	Range	0 – 75	0 – 15	6 – 39	0 – 16
	K-S (Sig.)	.178	.155	.168	.171

Legend: **“A”-** “A” program, **n, N**- number of study participants, **Mean**- average value, **SD**- standard deviation, **K-S-** Kolmogorov-Smirnov test**, Sig.-** significance, **B-ROL**- ball rolling over the arms, **R-TCJ**- throwing, catching and jumping through a rope, **H-SKP**- skipping through a hoop, **C-JUG**- clubs juggling.

•†‡◊Δ t-test (“A” vs. “B”): • p=0.019, † p=0.022, ‡ p=0.024, ◊ p=0.044, **Δ** p=0.049.

According to the cut-off points of coordination rating scale (Jastrjembskaia & Titov, 1999, 140), the "B" seniors have achieved excellent results in every out of four applied RG-specific coordination tests, and especially in tests B-ROL and H-SKP (8 out of 8, i.e. 100%), but also in test C-JUG (7 out of 8, i.e. 87.5%). More specifically, based on the average value of the coordination tests in this age group and program category, excellent results have been achieved in tests B-ROL, H-SKP and C-JUG, and good in test R-TCJ, which is very similar to the final outcome of the “A” seniors’ coordination. The situation in the subsample of the "B" junior RGs is similar to the seniors’: excellent scores in tests H-SKP (12 out of 12, i.e. 100%), B-ROL (11 out of 12, i.e. 91.7%) and C-JUG (10 out of 12, i.e. 83.3%); only in R-TCJ test one third of juniors performed it well, one third had fair and one third poor scores). Taking into account the average value of applied coordination tests (Table 5), the "B" advanced-level RGs have poorer results in comparison to the older age group categories and in relation to the "A" peers: excellent scores in H-SKP test achieved as much as 90% of “B” advanced-level RGs; good results were scored in tests C-JUG (7 out of 10, i.e. 70%) and B-ROL (5 out of 10, i.e. 50%), but poor in test R-TCJ (5 out of 10, i.e. 50%). In the subsample of the "B" intermediate-level RGs, excellent results were recorded in the case of H-SKP test (11 out of 11, i.e. 100%), while in case of the remaining three test the recorded results are spreading through the whole rating scale: in the first test (B-ROL) 27.3% of “B” intermediate-level RGs had an excellent score, but the same percentage of this subsample was also unsuccessful in the test; in the fourth test (C-JUG) 45.5% of “B” intermediate-level RGs have scored good results, while in case of the second test (R-TCJ) the highest percentage of this age group category (36.4%) have had poor scores. The

"B" beginners were the most successful in test H-SKP (6 out of 8, i.e. 75%); the highest percentage of them (62.5%, i.e. 5 out of 8) gain fair scores in C-JUG test, so as in case of B-ROL test (4 out of 8, i.e. 50%), while in R-TCJ test as much as 50% of this age group category did not manage to have a single successful attempt. When it comes to the distribution of coordination data in the group of "B" RGs, a statistically significant deviation is recorded in tests B-ROL (K-S, Sig.=0.012) and R-TCJ (K-S, Sig.=0.041) and only in the case of total "B" sample (see Table 5).

Table 5. Specific coordination in **"B"** RGs of different age group categories

Age Group Categories	Variables	B-ROL	R-TCJ	H-SKP	C-JUG
"B" Seniors (n=8)	*Mean±SD*	47.50±18.54	7.38±3.25	30.88±1.64	10.63±3.02
	Range	24 – 80	3 – 11	28 – 32	4 – 14
	K-S (Sig.)	.989	.931	.202	.498
"B" Juniors (n=12)	*Mean±SD*	26.58±17.24	3.67±2.39	31.33±4.58	11.0±3.05
	Range	7 – 58	1 – 7	25 – 38	6 – 16
	K-S (Sig.)	.811	.715	.914	.915
"B" Advanced (n=10)	*Mean±SD*	6.50±5.13	1.90±1.67	30.40±4.79	6.50±3.31
	Range	0 – 18	0 – 5	20 – 36	2 – 14
	K-S (Sig.)	.503	.791	.883	.691
"B" Intermediate (n=11)	*Mean±SD*	12.27±20.93	3.36±3.41	32.64±3.59	7.27±3.69
	Range	0 – 58	0 – 10	26 – 38	1 – 14
	K-S (Sig.)	.083	.716	.882	1.0
"B" Beginners (n=8)	*Mean±SD*	1.0±1.07	0.75±1.04	26.63±4.44	2.63±1.06
	Range	0 – 3	0 – 3	20 – 35	2 – 5
	K-S (Sig.)	.699	.559	.973	.290
Total "B" sample (N=49)	*Mean±SD*	18.51±21.47	3.37±3.20	30.59±4.34	7.82±4.16
	Range	0 – 80	0 – 11	20 – 38	1 – 16
	K-S (Sig.)	**.012***	**.041***	.312	.697

Legend: "B"- "B" program, **n, N-** number of study participants, **Mean-** average value, **SD-** standard deviation, **K-S-** Kolmogorov-Smirnov test**, Sig.-** significance, **B-ROL-** ball rolling over the arms, **R-TCJ-** throwing, catching and jumping through a rope, **H-SKP-** skipping through a hoop, **C-JUG-** clubs juggling.

*absence of normal distribution (significant at p=0.05)

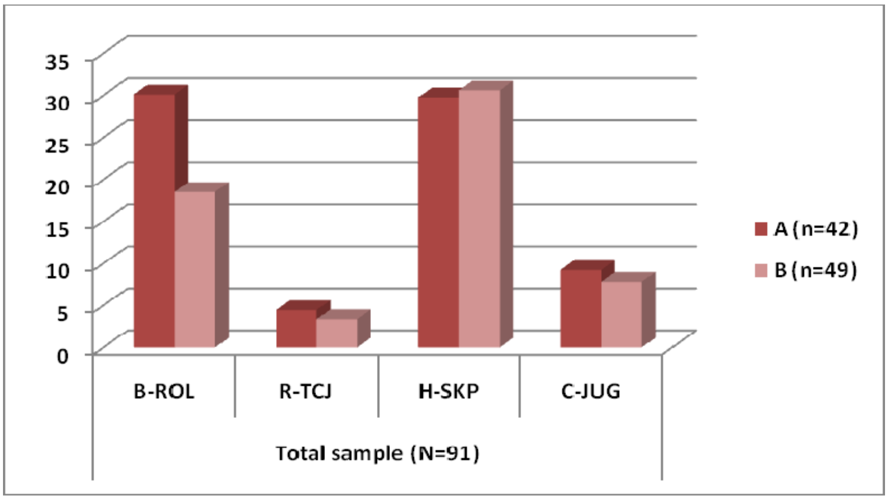

Figure 1. Values of specific coordination data recorded in RGs of different competition programs ("A" and "B")

Figures 1 and 2 are graphic comparisons of the obtained data for the "A" and "B" samples in total (Figure 1) and for the five subsamples within two competition programs (Figure 2). What we see in the Figures, the t-test has confirmed. Namely, the t-test results (Table 4) indicate the absence of statistically significant differences between "A" and "B" seniors', intermediate level RGs' and beginners' specific coordination. In case of junior RGs, the statistically significant differences were recorded only in test B-ROL (p=0.044), but those differences are of medium strength given that the value of eta is .406. When comparing subsamples of "A" and "B" advanced-level RGs, t-test points out not only on statistically significant differences in three out of four specific coordination tests (B-ROL: p=0.049, R-TCJ: p=0.022, C-JUG: p=0.019), but also on the great strength of those differences (eta values: .602, .642 and .563, respectively). The overall samples of "A" and "B" RGs differentiate in one coordination test only (B-ROL: p=0.024), but although the difference is statistically significant, it is not of great strength (eta value is .240). At multivariate level (Discriminant canonical analysis) the statistically significant differences are absent.

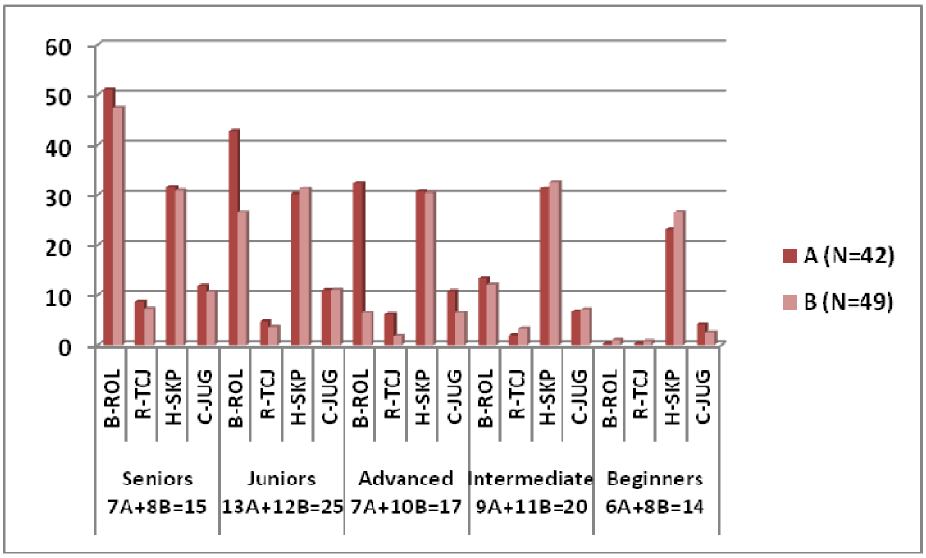

Figure 2. Values of specific coordination data recorded in RGs of different age group categories (seniors, juniors, advanced-level, intermediate-level and beginners) and competition programs ("A" and "B")

DISCUSSION AND CONCLUSION

In order to examine the differences between the RGs competing in different competition programs, a study was conducted on the sample of 91 national and international RGs, aged 7 to 20 years. By using the appropriate statistical procedures, the status of the specific coordination skills was determined for each of two competition programs, for each age group category separately (a total of five), as well as for the sample in total, and then the possible presence of differences between an "A" and "B" RGs in specific coordination was tested. When introspected, all of the obtained results indicate the presence of differences in specific coordination of the "A" and "B" RGs, which is in accordance with the study results of Zisi, Giannitsopoulou, Vassiliadou, Pollatou, & Kioumourtzoglou (2009). Although the most of those differences are not at statistically significant level, they are mostly in the favor of an "A" RGs, except in the case of younger age group categories. Namely, when it comes to comparison of specific coordination of an "A" and "B" intermediate-level RGs and beginners, the scores of "B" RGs are the ones that contribute the differentiation. Thus, the "A" intermediate-level RGs have scored better results in test B-ROL, and the "A" beginners in test C-JUG. In the remaining tests the better results are achieved by the "B" intermediate-level RGs and the beginners. These results, i.e. more successful performance of specific coordination test by peers of lower competition program, may point out to the fact that the "B" RGs were more motivated to be successful in carrying out the given tasks. Their motivation can be explained by the fact that those are interesting tasks to them having in mind that they do not have the often opportunity to practice these elements during the training lessons, unlike an "A" RGs. When it comes to the older age group categories, the "A" seniors and advanced-level RGs are completely dominant in comparison to their “B” peers, and there is a good reason for this. In fact, one of the major differences between the two competition programs is the number of routines performed at individual competitions. Namely, as individual competitors “B” RGs have to perform two routines in total, and each with different apparatus by their choice, while “A” contestants have to perform four routines in total, and each time with the different apparatus (which four out of total five apparatus are obligatory to “A” RGs is the decision that is made every four years and is regulated by Code of Points). This could mean that the RG apparatus techniques in "A" RGs is at much higher level than “B” RGs, because they are obliged to an equal exercising with all RG apparatus, while "B" RGs have the opportunity of choosing two apparatus to practice with, which is why we can expect the significantly reduced techniques quality with the rest of the apparatus (in case of “B” contestants). As for the junior RGs, the situation is not entirely in favor of the "A" contestants, i.e. “A” juniors have achieved better results in the tests with ball and rope, and "B" juniors in the tests with hoop and clubs. The reasons for this outcome can be found in the fact that the tests of coordination with the ball, so as with the rope, are technically demanding in comparison to the tests with hoop and clubs. Namely, for the successful apparatus handling and performing of these fundamental apparatus techniques with ball and rope, many hours of hard training and techniques repetitions are necessary for reaching the perfection.

This research has established and confirmed the existence of the differences between the RGs competing in two different competition programs, with most of the obtained results in favor of the "A" RGs, which was expected and which had unambiguously confirmed us the contribution of RGs’ specific coordination skills to successful and progressive RG performance. These results could be a good indicator to RG coaches for proper guidance of training processes in RGs of different ages and levels of competition, which could certainly contribute to improving their athletic performance and enabling them to progress in the ranks of the competition.

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INFLUENCE OF RELATIVE FORCE ON ALL-AROUND COMPETITION RESULT WITH GYMNASTS

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UDC 796.41:012.1

SUMMARY

The aim of this study was to investigate the influence of the relative force of different muscle groups on the result in all-around competition. The sample of respondents for the research purposes consisted of 16 gymnasts from Serbia, Bulgaria, Slovenia, Austria, Croatia, Switzerland and South Africa, aged 14 to 16 (avg 15,19) and body weight from 33 kg to 58 kg (avg 44,38 kg). Respondents had a training experience from six to nine years (avg 7.44). For the assessment of maximum muscle force were measured: maximum muscle force of back extensors (BACMAX), maximum muscle force of knee extensors (LEGMAX), maximum muscle force of the upper arm flexors (BICMAX) and maximum force of the shoulder muscles (SHOMAX). The Japanese digital IMADA Z2H-1100 with the WinWedge 3.4 software was used to measure the maximum muscle force of the above-mentioned muscle groups. For the evaluation of the results in all-around competition the sum of „D“ and „E“ score on all apparatus was used (SCORE). For all variables descriptive statistics and regression analyse were used in order to determine the influence of muscle force on result in all around competition. The results of the regression analysis have shown that there is no statistically significant influence of the set of variables on the result in the all-around ($p = 0.653$), nor with any variable in particular (BACMAX = 0.841, LEGMAX = 0.413, BICMAX = 0.926, SHOMAX = 0.149). The reason for the results obtained in this study should be sought in the age of the respondents. Namely, at this age, the result is influenced by a number of factors. One of them is the technical preparation of gymnasts as well as level of training. Another factor influencing the result is the number of competitions at which gymnasts participated. A larger number of competitions allows competitor to gain the necessary experience and reduce the influence of nervousness and anxiety on the result. Finally it should be noted that this study is an excellent base for further researches of muscular force in artistic gymnastics on a different sample of respondents and different muscle groups.

Keywords: artistic gymnastics, muscle force, all-around, gymnasts

INTRODUCTION

Artistic gymnastics is considered as one of the most demanding physical sports that do not suffer disadvantage in the development of any motor skills. The most difficult discipline in artistic gymnastics is certainly all-around competition, where the gymnast should display his best performance on all apparatus. The victory in all-around competition represents the greatest success for gymnast. Under artistic gymnastics, the widest audience is experiencing sports, conceptually defined as a competitive discipline, of polystructural content (exercises are performed in all three levels of movement and around all three axes of rotation), acyclic type with strictly defined rules as a convention in practice. Exercises in artistic gymnastics are very diverse and some of them are more demanding in terms of different forms of strength, some in terms of coordination, flexibility, balance, and some sublimate more motor skills. For this reason, the application of exercises on the apparatus and floor indisputably affects the overall motor status of a person (Petković, Veličković, Petković, Hadži – Ilić, i Mekić, 2013). Strength as one of the motor skills, is defined as the ability of a man to oppose any outside force by muscle contraction or to move their own body (Stojiljković, 2003). Opavski (1971) identifies strength with force and says that the „force is the ability to transform muscular contraction in the composition of motor units into a kinetic or potential form of mechanical energy“. The most common criterion for the classification of strength is the relationship between the force exerted and the body mass. On this basis it is possible to isolate: absolute strength (maximum muscular strength that man can develop with his overall muscle mass) and the relative strength (the amount of strength it can develop per kilogram of its weight) (Stojiljković, 2003). Relative strength in artistic gymnastics is more significant than absolute. The reason for this is the fact that gymnasts, when performing the elements and the whole composition, carry exclusively their own body, without additional external load. Because of all the above, it is important to determine whether there is an influence of relative forcce on the success in all-around competition wuth gymnasts, which is the aim of this research.

METHODS

Subjects

The sample of respondents for the research purposes consisted of 16 gymnasts from Serbia, Bulgaria, Slovenia, Austria, Croatia, Switzerland and South Africa, aged 14 to 16 (avg 15,19) and body weight from 33 kg to 58 kg (avg 44,38 kg). Respondents had a training experience from six to nine years (avg 7.44). All methods and procedures of this investigation were approved by the ethical committee of the University of Niš, Faculty of Sport and Physical Education, Serbia, and they conformed to the Code of Ethics of the World Medical Association (Declaration of Helsinki).

Procedure

All tests were taken in one day. For the assessment of maximum force were measured: maximum force of back extensors (**BACMAX**), maximum force of the leg extensors (**LEGMAX**), maximum muscle force of the upper arm flexors (**BICMAX**) and the maximum force of the shoulder muscles (**SHOMAX**). The Japanese digital IMADA Z2H-1100 with the WinWedge 3.4 software was used to measure the maximum muscle force. The value displayed on the digital meter is the absolute value of the maximum force. When the absolute value of the force is divided by the weight of the participants, the relative force value is obtained. For evaluation of results in the all-around competition was used summation of "D" and "E" score (**SCORE**) on all apparatus at the international tournament „Laza Krstić i Marica Dželatović“, held in Novi Sad. Measurement of body weight was done according to the recommendations of the international biological program (Đurašković, 2001). For the measurement of body weight was used electronic scale brand „Tefal“ with measurement accuracy of 0.1 kg.

For measuring the maximum force of back extensors participant occupies a standing position with feet separated in the width of the hips. The body of the participant is slightly bent. With the straight arms, the subject holds the digital force gauge in front of him. The chain that connects the digital force meter with the stand is fully taut. Respondent from the initial position pulls the dynamometer evenly with the strength of the muscle of the posterior-lumbar muscle extensors, rectifying in the shoulder and upper part of the chest, where the arms are straight. The result is expressed in newtons (N). The test description was taken from Dopsaj, 2010.

For measuring the maximum force of leg extensors participants holds a dynamometer behind and under the back, where the knees are in a mild flexion and the feet are spaced apart in the width of the hips. The chain that connects the digital force meter with the stand is fully taut. Respondent from the initial position pulls a dynamometer with uniformly extended arms by the force of the muscles of the lower extremity extensors, during which performs extension in the knee joint. The result is expressed in newtons (N). The test description was taken from Dopsaj, 2010.

For measuring the maximum muscle force of the upper arm flexors respondent holds dynamometer in front of him with flexion in elbow joint of 90 degrees. The feet are spaced apart in the width of the hips and the chain that connects the digital force meter with the stand is fully taut. Respondent from the starting position pulls the dynamometer with both hands evenly by the strength of the flexors of the upper arm, during which performs flexion in the elbow joint. The result is expressed in newtons (N). The test description was taken from Dopsaj, 2010.

For measuring the maximum force of shoulder muscles respondent holds dynamometer in front of him, with extended arms with a 90 degree angle between arm and body. The feet are spaced apart in the width of the hips and the chain that connects the digital force meter with the stand is fully taut. Respondent from the starting position pulls the dynamometer with both hands evenly with strength of the shoulder muscles, during which he performs ante-flexion in the shoulder joint. The result is expressed in newtons (N). The test description was taken from Dopsaj, 2010.

Statistical analysis

For each variable were first calculated descriptive parameters, for this purpose were calculated:

- Minimum value (MIin),
- Maximum value (Max),
- Aarithmetic mean (Mean),

- Standard deviation (Std),
- Coefficient of variation (CV),
- Kolmogorov-smirnov Z test (p).

A regression analysis was used to determine the influence of the relative strength variables on the competition results in all around, where the following statistical parameters were calculated: **Beta** = Standardized regression coefficients values, **t** = Standardized regression coefficients significance tests, **p** = Standardized regression coefficients level of significance, **R**= Multiple correlation coefficient, **R2 adjust** = Adjusted determination coefficient, **Std. Err. Est.** = Standard error of the estimate, **F** = Multiple regression analysis significance tests, **p** = multiple correlation level of significance. The data obtained in this research were processed by the statistics package „SPSS v20".

RESULTS

Table 1. Descriptive statistics

Variables	n	Min	Max	Mean	Std	CV	p
BACMAX	16	13.13	24.39	18.78	3.46	18.40	.604
LEGMAX	16	10.57	24.66	17.42	4.61	26.48	.520
BICMAX	16	4.03	18.31	6.44	3.39	52.71	1.180
SHOMAX	16	1.00	3.11	2.35	0.54	23.08	.699
SCORE	16	53.95	75.80	64.57	5.06	7.84	.655

Legend: **BACMAX** – back extensor relative muscle force, **LEGMAX** – leg extensor relative muscle force, **BICMAX** – upper arm flexor relative muscle force, **SHOMAX** – shoulder muscle relative muscle force, **n** – number of participants, **Min** – lowest score, **Max** – highest score, **Std** – standard deviation, **Mean** – mean, **CV** – coefficient of variation, **p** – Kolmogorov Smirnov Z test

Table 2. Regression analysis

Variables	Beta	t	p	R	R^2_{adjust}	Std. Err. Est.	F	p
BACMAX	.089	.205	.841	.431	-.110	5.336	.627	.653
LEGMAX	-.405	-.851	.413					
BICMAX	-.026	-.095	.926					
SHOMAX	.499	1.551	.149					

Legend: **BACMAX** – back extensor relative muscle force, **LEGMAX** – leg extensor relative muscle force, **BICMAX** – upper arm flexor relative muscle force, **SHOMAX** – shoulder muscle relative muscle force, **Beta** – standardized regression coefficients values, **t** – standardized regression coefficients significance tests, **p** – standardized regression coefficients level of significance, **R** – multiple correlation coefficient, **R^2 adjust** – adjusted determination coefficient, **Std. Err. Est**. – standard error of the estimate, **F** – multiple regression analysis significance tests, **p** – multiple correlation level of significance

Table 1. shows the results of descriptive statistics for all applied variables. Results of Kolmogorov-Smirnov Z test (**p**), which are in all applied variables greater than 0.05, indicates that there is no significant deviation from normal distribution. The coefficient of variation results (**CV**) indicates that only one variable (**BICMAX**) has a relatively strong variability, while others have relatively low variability. Table 2. shows the results of the regression analysis for each variable in particular, as for set of variables. The results indicates that the influence of the relative force on the result in all-around competition with gymnasts, although exists, it is not statistically significant. With set of variables, the obtained results are at the level **p** = 0.653. For each variable separately, influence closest to statistical significance was obtained with the variable for evaluation of relative force of shoulder muscles – **SHOMAX** (p = 0.149) and leg extensor muscles – **LEGMAX** (p = 0.413), while with variables for the evaluation of relative force of back extensor muscles – **BACMAX** (p = 0.841) and flexor muscles of the upper arm – **BICMAX** (p = 0.926) this impact is significantly lower and statistically insignificant. In support of these results are the results of standard regression coefficients, which indicates on greatest influence of the variables for estimating the relative force of shoulder muscles – **SHOMAX** (t = 1.551) and leg extensor muscles – **LEGMAX** (t = -0.851), and a smaller influence of variables for estimating relative force of back extensor muscles – **BACMAX** (t = 0.205) and flexor muscles of the upper arm – **BICMAX** (t = -0.095).

DISCUSSION AND CONCLUSION

The aim of this study was to investigate the influence of the relative force of different muscle groups on the result in all-around competition. The results showed that there is no statistically significant influence of the relative force, as for each variable so as not on set of variables. As in artistic gymnastics there are no studies that have dealt with this issue, there was no possibility of comparing the results obtained in this research. In other sports in the research conducted by Garrido et al. (2012) obtained was connection between the maximum isometric force of the hand grip and results of swimmers at 100m freestyle. Dopsaj, Ivanović, Blagojević & Vučković (2009) are in their research came to the results which point to the greater force of the hand grip of weightlifters than normal and well-trained fourth year students of the Academy of Criminology and Police Studies. To results which indicates that top athletes and people who are not involved in sports have the same ability to develop leg extensors muscles muscle force, in their research came Ivanović et al. (2012). The abovementioned studies represents good idea for further researches in artistic gymnastics. Given that in artistic gymnastics gymnasts have a grip for apparatus on four from six apparatus, in future studies could be checked connection and influence of hand grip force on result at these apparatus. Also should be compared the maximum and the relative force of different muscle groups between the gymnasts and the people who are not involved in sports.

The reason for the results obtained in this research should be sought in the age of the subjects. Namely, at this age, the result is influenced by a number of factors. One of them is the technical preparation of gymnasts as well as level of training. Another factor influencing the result is the number of competitions at which gymnasts participated. A larger number of competitions allows competitor to gain the necessary experience and reduce the influence of nervousness and anxiety on the result. Finally it should be noted that this study is an excellent base for further researches of muscular force in artistic gymnastics on a different sample of respondents and different muscles.

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LONGITUDINAL AND TRANSVERSAL COMPARISONS OF MORPHOLOGICAL CHARACTERISTICS AND MOTOR ABILITIES OF TWO GENERATIONS OF COMPETITORS IN ALPINE SKIING

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SUMMARY

The study compares morphological characteristics and motor abilities of two generations (2006 and 2016) of competitors in Alpine skiing in the longitudinal and transversal way. The subject sample included 71 young girls and boys, competitors in category U16 (14 and 15 years old). We made comparison of two morphological (body weight and body height) and three motor variables (standing triple jump, ten consecutive double leg jumps and figures 8 around 9 clubs) from the model of potential successfulness from years 2006 and 2016.

Longitudinal/intergenerational comparisons of boys showed that the younger generation (2016) is 6 kg heavier compared to the older one (2006). On the other hand the comparison with girls shows that the younger generation (2016) is lighter. A transversal comparison of selected morphological variables between young boys and girls shows statistically significant differences in 3 of the 4 cases.

The results of longitudinal/intergenerational comparisons of motor abilities of boys and girls are not statistically significant. The difference is noticeable only at the variable of strength which shows better results in the younger generation of boys. That can be the consequence of a better program of training strength over the last years. A transversal comparison of motor abilities between girls and boys shows statistically significant differences in 5 of the 6 comparisons. In both generations, the value tends to the benefit of boys in strength and coordination, with higher deviations in the younger generation.

The findings of our study are similar to the findings of the expert public in the field of Alpine skiing. According to that the younger generations of competitors in Alpine skiing are better in terms of morphological characteristics and motor abilities. That means that their morphological and motor basis allows them more possibilities for competitive successfulness. According to the results, which are related to the ability of various forms of strength and coordination, it is suggested the training program to be separate for boys and girls. On the other hand we know that group trainings also have many benefits, which are primarily related to social reasons.

Keywords: alpine skiing, younger categories, morphological characteristics, motor abilities, differences, training planning

INTRODUCTION

Alpine skiing is a complex sports discipline the competitive success of which is influenced by numerous mutually correlated factors (Bandalo, 2016; Žvan, & Lešnik, 2000). It is proven that success in this sport is most strongly influenced by the level of development of individual's motor abilities, which are – especially in younger categories – mainly determined by individual's physique (Dolenec, 1996; Lešnik, 1996; Lešnik, Sekulić, Supej, Esco, & Žvan, 2017). The fact is also proven by numerous researches carried out in other sports disciplines regarding the influence of basic and specific motor abilities and other factors influencing success (Jošt, Pustovrh & Ulaga, 1998). Our restudy was thus focused on selected morphological and motor dimensions, which – according to the findings of many researches - significantly influence the success of young athletes in Alpine skiing especially in adolescent period. There are many studies dealing with the developmental differences between boys and girls in adolescence. Adolescence is a period of fast growth (»adolescent growth spurt«), sexual development and changes in nervous and hormonal system (Boisseau & Delamarche, 2000; Cobb, 2007; Eriksson, Gollnick & Saltin, 1973; Meece, 2002; Škof & Kalan, 2007). In the period of fast growth teenagers experience the increase in body height and also the growth of other body parts that do not grow proportionally. This results in disturbing motor patterns and possible stagnation or even anti-progress of motor abilities. In the period of adolescence girls develop physically and mentally faster than boys. Thus there are differences in body constitution, physical fitness, motor potential and other characteristics of psychosomatic status between boys and girls. Compared to boys, girls have wider hips whereas boys have a wider shoulder ring. There is also a significant difference in body fat; girls store more body fat and muscle mass; boys have more muscle mass (Berk, 1997; Gorski, Rosser, & Hoppeler, 2014; Malina, Bouchard, & Bar-Or, 2004).

Due to all developmental changes adolescence is a sensitive time for competitors (Tsolakis, Messinis, Stergioulas & Desypris, 2000). Since our goal is to optimise young competitors' training we should consider the differences among young skiers as an important factor – we should consider whereas mutual and similar training for boys and girls is reasonable. Alpine skiing trainers of young competitors face the problems of morphological and motor differences between boys and girls (at trainings and competitions) and therefore training must be adjusted to individuals (SAS, 2015). When working with a group of competitors such an adjustment does not have a desired effect and it is more expensive. Ski clubs and national youth teams therefore question whereas joint training of boys and girls is the best solution.

The main goal of the research is to establish whereas there are statistically significant differences in measured dimensions of morphological and motor status between boys and girls in generation 2006 and generation 2016 (transversally). Over the years fitness preparation has been adjusted to the changes in skiing technique. Today, the training process emphasizes various kinds of strength, mainly exercising single leg push-off and double-leg push-off strength and various forms of specific coordination (Grosser, Starischka & Zimmermann, 2004). Our goal was therefore to determine whereas there were intergenerational differences in morphological and motor dimensions in the period of a decade (from 2006 to 2016) that could influence the quality of training in Alpine skiing (longitudinally).

METHODS

Subjects

The research used data of the measurement of morphological and motor dimensions of young categories in Alpine skiing. The measurements are carried out at least once a year prior to skiing season at the Faculty of Sports in Ljubljana. The results show the level of readiness of competitors prior to the competition period.

The subject sample consists of four groups – two generations of boys and girls aged 14 and 15 in category U16, namely:

Gen1M06 – 13 older boys born in 1992 with results from 2006,

Gen1W06 – 8 older girls born in 1992 with results from 2006

Gen2M16 – 26 older boys born in 2002 with results from 2016,

Gen2W16 – 24 older girls born in 2002 with results from 2016.

Variable sample

In accordance with the research goals we chose variables that were tested in 2006 and 2016. Thus we got morphology variable (BH-body height and BW-body weight) and motoric variable (SKI9 – figures eight around 9 poles, MSKOK10- ten consecutive double leg jumps and MMEN3SM-standing triple jump). The descriptions of tests can be found in Appendix of PhD paper by Miha Bandalo (Bandalo, 2016).

Statistical analysis

Data was processed by SPSS program – statistical package for social sciences. As regards longitudinal comparisons, intergenerational differences were calculated for boys during 2006 - 2016 and for girls during 2006 - 2016. Transversal comparisons were used to establish differences according to gender (boys and girls) in generation 2006 and 2016. The calculation of basic statistic parameters consists of the calculation of average values ($\bar{x}$) and standard deviation (SD). Distribution normality (Shapiro-Wilk test) and variance homogeneity (Levene's test) were tested in all variables. The comparison in selected morphological and motor variables was tested by T-test for independent samples or by Mann-Whitney test.

RESULTS AND DISCUSSION

The results of longitudinal comparison of physical characteristics between boys and girls of generation 2006 are shown in Table 1. We carried out 8 comparisons altogether, four intergenerational comparisons of morphology variables in longitudinal way and four intergenerational comparisons of morphology variables in transversal way.

The results of longitudinal comparisons of generations of boys and girls from 2006 and 2016 regarding body weight and body height (Table 1) show that the two generations differ significantly.

Table 1. Longitudinal comparisons of two generations of boys and girls in body weight and body height

Variable	Gender	Generation	N	μ	S.D.	t	p
BW (kg)	Boys	Gen1M06	13	56,15	8,88	-2,804	**0,008***
		Gen1W06	26	62,15	4,55		
	Girls	Gen2M16	8	55,28	6,16	1,879	0,070
		Gen2W16	24	51,19	5,04		
BH (cm)	Boys	Gen1M06	13	168,78	5,73	-1,583	0,122
		Gen1W06	26	172,27	6,84		
	Girls	Gen2M16	8	162,03	6,22	-1,006	0,322
		Gen2W16	24	163,83	3,65		

Legend: BW-body weight; BH-body height; Gen1M06 – 13 older boys born in 1992 with results from 2006; Gen1W06 – 8 older girls born in 1992 with results from 2006;Gen2M16 – 26 older boys born in 2002 with results from 2016;Gen2W16 – 24 older girls born in 2002 with results from 2016;.N-number of measured sample; μ-mean; S.D.-standard deviation; t-test value; p-statistical significance at the level of 5%*

Intergenerational (longitudinal) comparisons regarding boys' body weight (BW) shows that the younger generation 2016 is as much as 6 kilograms heavier compared to the older one (generation 2006). The differences are statistically significant at risk level of 5% (p=0,008). Comparisons of differences between the two generations of girls show the opposite. Values of body weight variables are by 4 kilograms higher in older generation (2006). The results are on the limit of statistical significance (p=0,070). Intergenerational differences of boys' body weight are due to significant changes in training process and larger emphasis on training various forms of strength. Consequently, the increase in body weight due to the increase of muscle mass is one of the expected consequences of implementing new contents in training process. Although the intergenerational comparison of girls shows that the younger generation is physically lighter we must consider the fact that the sample of girls from 2006 was small and thus less representative (N=8). Decrease in girls' body weight may be due to better nutritional habits and also due to individual approach of training which is based on overall development of young female competitors.

Longitudinal comparisons in the variable of body height (BH) do not show any statistically significant differences. The comparisons show that the younger generation of boys (Gen1M06) and girls (Gen1W06) is taller than the older generations (Gen1M06 in Gen1W06). This is mainly due to genetics and the fact that today we are more aware of negative effects of irregular training process. The latter is especially evident in training of various forms of strength, which may influence body height in a negative way. This is the reason why we must avoid using weights during exercise in the period of body development. However, it is important to make training as effective as possible.

Below there are transversal comparisons between boys and girls born in 1992 and 2002 regarding body weight and body height (Table 2).

Table 2 shows the comparison of boys and girls between generations 2006 and 2016 in body weight (BW) and body height (BH). As regards BW, the calculation of comparison between boys and girls in generation 2006 does not show statistically significant differences (p=0,809). In generation 2006 boys were nearly a kilogram heavier than girls, as shown in the table, whereas the differences in BW between boys and girls in generation 2002 were larger and statistically significant at risk level of 1% (p=0,000). In generation 2002, boys were as much as 10.96 kilograms heavier. The results correspond to the findings of longitudinal comparisons that confirm statistically significant intergenerational differences between boys of the younger generation and boys in the older generation (Table 1). We can conclude that the difference in BW between boys and girls is due to the increase of muscle mass of boys and due to the differences in their height.

The results of comparison of boys and girls in BH prove statistically significant differences in favour of boys in younger as well as in older generation of subject sample. Boys in generation 2006 were averagely 6.75 centimetres taller than girls, whereas boys in generation 2016 were averagely 8.44 centimetres taller than girls. The older generation (2006) statistically significantly differs from the younger generation (2016) in BH (p=0,020), whereas the comparison of boys and girls in generation 2016 shows the differences in favour of boys - statistically significant at risk level of 1% (p=0,000).

The second goal (C2) was to examine motor status – we tried to establish the differences in motor abilities of boys and girls in generations 2006 and 2016. The results of longitudinal comparison of motor tests of boys and girls in generation 2002 are shown in Table 3. Transversal comparisons of boys and girls in generations 2006 and 2016 in variables SKI9, MSKOK10 and MMEN3SM are shown in Table 4. We carried out 12 intergenerational comparisons of motoric altogether - 6 in longitudinal and 6 in transversal way.

Table 2. Transversal comparisons of boys and girls in generations 2006 and 2016 in body weight and body height

Variable	Born	Generation	N	μ	S.D.	t	p
BW (kg)	1992	Gen1M06	13	56,15	8,88	0,245	0,809
		Gen1W06	8	55,28	6,16		
	2002	Gen2M16	26	62,15	4,55	8,077	**0,000****
		Gen2W16	24	51,19	5,04		
BH (cm)	1992	Gen1M06	13	168,78	5,73	2,541	**0,020***
		Gen1W06	8	162,03	6,22		
	2002	Gen2M16	26	172,27	6,84	5,384	**0,000****
		Gen2W16	24	163,83	3,65		

*Legend: BW-body weight; BH-body height; Gen1M06 – 13 older boys born in 1992 with results from 2006; Gen1W06 – 8 older girls born in 1992 with results from 2006;Gen2M16 – 26 older boys born in 2002 with results from 2016;Gen2W16 – 24 older girls born in 2002 with results from 2016;.N-number of measured sample; μ-mean; S.D.-standard deviation; t-test value; p**-statistical significance at the level of 1%; p*-statistical significance at the level of 5%.*

Table 3. Longitudinal comparisons of two generations of boys and girls in selected motor tests

Variable	Gender	Generation	N	μ	S.D.	t	p
MMEN3SM (cm)	Boys	Gen1M06	13	640,31	66,90	-2,368	**0,023***
		Gen1W06	26	691,54	62,11		
	Girls	Gen2M16	8	602,75	32,07	-0,326	0,747
		Gen2W16	24	607,67	38,27		
MSKOK10 (m)	Boys	Gen1M06	13	22,02	2,02	-1,391	0,173
		Gen1W06	26	23,16	2,56		
	Girls	Gen2M16	8	20,14	1,31	-1,240	0,225
		Gen2W16	24	20,88	1,51		
SKI9 (s)	Boys	Gen1M06	13	31,52	4,36	0,882	0,383
		Gen1W06	26	30,58	2,29		
	Girls	Gen2M16	8	33,65	1,84	1,774	0,086
		Gen2W16	24	32,21	2,03		

*Legend: MMEN3SM-standing triple jump; MSKOK10-ten consecutive double leg jumps;SKI9-figures eight around 9 poles; Gen1M06 – 13 older boys born in 1992 with results from 2006; Gen1W06 – 8 older girls born in 1992 with results from 2006;Gen2M16 – 26 older boys born in 2002 with results from 2016;Gen2W16 – 24 older girls born in 2002 with results from 2016;.N-number of measured sample; μ-mean; S.D.-standard deviation; t-test value; p**-statistical significance at the level of 1%; p*-statistical significance at the level of 5%*

The results of longitudinal comparisons of generations of boys and girls born in 1992 and 2002 in variables MMEN3SM MSKOK10 and SKI9 (Table 3) show that the two generations compared do not differ much in the quality of motor status. Intergenerational comparisons of boys and girls show statistically significant differences in favour of the younger generation of boys (2006) only in variable MMEN3SM (p=0,023). This variable shows the differences of more than half a metre in favour of the younger generation, which might be the result of giving more emphasis to single-leg push-off strength in the process of transformation of young competitors in Alpine skiing. One of the reasons is the interpretation of modern competition technique which has been based on quick pressuring of the upper ski, later the outer ski in turn. (Puhalj, 2018). The comparison of variable MMEN3SM for girls shows differences in favour of the younger generations (2006) – the difference was a little less than 5 centimetres. Comparisons between boys and girls in other two variables (SKI9 MSKOK10) were not statistically significant nevertheless they show the improvement in the results of the younger generation. Comparisons in variable Ten consecutive double leg jumps show that the younger generation was better than the older one by little less than a metre (boys) and 74 centimetres (girls). In the variable of coordination (SKI9) boys and girls in the younger generation (2016) achieved better results. Although the differences were not statistically significant there is one important thing - the difference in the variable of realisation of complete programmes of motoric is better by almost 1 second (boys) and a bit over a second (girls).

On one hand the results support the orientation and characteristics of training younger categories – more time is devoted to single-leg push-off strength. It is important to emphasize coordination – which is based on the development of other motor skills - as one of the training contents. It is shown in variable SKI9. In their researches Bandalo and Lešnik found a high correlation between the variables of push-off strength and coordination and competition successfulness (Bandalo & Lešnik, 2011). Only the variable of single-leg push-off strength stands out, whereas the comparison of double-leg repetitive push-off strength did not show any statistically significant differences.

Table 4. Transversal comparison between boys and girls in generations 2006 and 2016 in selected motor tests

Variable	Born	Gender	N	μ	S.D.	t	p
MMEN3SM (cm)	1992	Gen1M06	13	640,31	66,90	1,476	0,156
		Gen1W06	8	602,75	32,07		
	2002	Gen2M16	26	691,54	62,11	5,691	**0,000****
		Gen2W16	24	607,67	38,27		
MSKOK10 (m)	1992	Gen1M06	13	22,02	2,02	2,347	**0,030***
		Gen1W06	8	20,14	1,31		
	2002	Gen2M16	26	23,16	2,56	3,784	**0,000****
		Gen2W16	24	20,88	1,51		
SKI9 (s)	1992	Gen1M06	13	31,52	4,36	-2,428	**0,013***
		Gen1W06	8	33,65	1,84		
	2002	Gen2M16	26	30,58	2,29	-2,904	**0,003****
		Gen2W16	24	32,21	2,03		

*Legend: MMEN3SM-standing triple jump; MSKOK10-ten consecutive double leg jumps;SKI9-figures eight around 9 poles; Gen1M06 – 13 older boys born in 1992 with results from 2006; Gen1W06 – 8 older girls born in 1992 with results from 2006;Gen2M16 – 26 older boys born in 2002 with results from 2016;Gen2W16 – 24 older girls born in 2002 with results from 2016;. N-number of measured sample; μ-mean; S.D.-standard deviation; t-test value; p**-statistical significance at the level of 1%; p*-statistical significance at the level of 5%*

Table 4 shows transversal comparison between boys and girls in generations 2006 and 2016 in variables MMEN3SM, MSKOK10 and SKI9. All differences (except MMEN3SM; generation 1992) between boys and girls were statistically significant in the older and the younger generation. The difference between boys and girls in standing triple jump in generation 2006 was a little less than 40 centimetres, whereas the difference in younger generation was 83.87 centimetres (p=0,000) in favour of boys.

In the variable MSKOK10 there were statistically significant differences between boys and girls in both generations at the risk level of 1%. The difference in the older generation (2006) was 188 centimetres (p=0,030) in favour of boys, whereas the difference in the younger generation was 228 centimetres (p=0,000). The difference between boys and girls was statistically significant in the variable of coordination (figures eight around 9 poles), boys in generation 2006 were 2 seconds faster than girls, whereas boys in the younger generation were 1.63 seconds faster than girls.

The differences were statistically significant in 6 comparisons out of 12 - therefore the goal of our research was reached. The findings of this research thus offer some answers to the question of whether boys and girls should be trained together. According to the results – mainly regarding various forms of strength and coordination – it is advisable to train boys and girls separately. However, we are all aware of the fact that joint trainings also have some advantages, mainly social.

CONCLUSION

The research proved that there exist statistically significant differences in morphological and motor dimensions in transversal as well as in longitudinal way. Statistically significant differences were shown in half of the variables by T-test (among twenty longitudinal and transversal differences). Four variables of morphology out of eight were statistically significant, and six variables of motoric out of twelve were statistically significant. The results empirically support the findings of professionals in skiing: a) the physique of today's generations of younger categories of competitors is more suitable for competitive Alpine skiing regarding body weight and body height and b) the effects of systematic fitness preparation are reflected in better conditional preparation and higher level of motor skills as compared to competitors 10 and more years ago.

Planning and organisation of training in Alpine skiing demands individual treatment of each competitor, however trainings are still organised for groups of competitors due to limited financial resources. Due to the differences that occur among younger generations of competitors there is a dilemma of additional needs and possibilities of adjusting training of younger categories in Alpine skiing (Lešnik, & Žvan, 2010). Although the issue has been debated for quite some time, the problem has always been – money. Financial problems always bring new questions as to how to enable proper training conditions and consequently international competitiveness.

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THE INFLUENCE OF BODY COMPOSITION AND FLEXIBILITY ON SHOT VELOCITY IN GOALBALL – A PILOT STUDY

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SUMMARY

The aim of this research is to determine the influence of body composition and flexibility on shot velocity in goalball. The sample of respondents consisted of 21 goalball players aged 24 to 39, members of five national selections (Serbia, Bosnia and Herzegovina, Montenegro, Sweden, Bulgaria), with at least five years of sports experience on the national and one year on the international level. The sample of the variables was divided into two subunits: body composition and flexibility (predictor set of variables) and the shot velocity (criterion variable). Body composition is analyzed by following variables: Body height (BH), Body mass (BM), Fat free mass (FF), Visceral fat (VF) , Body mass index (BMI) and Skeletal muscles mass (SMM). Flexibility is analyzed by following variables: Deep bend on the bench (DBB), Stick exercises (SE), Trunk extension (TE) and Seat and reach test (SRT). The shot velocity (SV) was measured using the radar. Descriptive statistics, Pirson's correlation and a regression analysis were used for data processing. The group effects of the predictor variables (body composition and flexibility) on the criterion variable SV was determined.

Keywords: body composition, flexibility, shot, goalball.

INTRODUCTION

Golbal is a sport for people with visual impairments that arose after the Second World War in order to physically and socially rehabilitate people with visual impairment (Грлица et al., 2016). In the meantime, goalball was developing, so it became the oldest sports game for people with visual impairment in Paralympic Games program (Tweedy & Vanlandewijck, 2010). The goalkeeper is playing in the field as well as the volleyball court (18m x 9m), and the goal extends over the entire width of both sides of the field (9m x 1.3m). Each player has to have covered eyes with a special mask (regardless of the size of visual impairment), and a special ball contains a bell for the perception of its position by the player (Krzak et al., 2015). The team is represented by three players in the field who are in front of their goal who defended their bodies in the defense phase, and after that they are shooting at the opponent's goal (Gulick & Malone, 2011).

The shot is one of the most important technical elements in the goalball and through expert opinion it is one of the most important preconditions for victory (Bowerman et al., 2015). On the other hand, the most recent research from the last Paralympic Games in Rio de Janeiro 2016 shows that shot velocity is the first precognition of scoring, independently from shot trajectory and type of the goalball balls (Morato et al., 2018). Moreover, the shot is part of some of the game elements that define the winner in the goalball game (Jorgić et al., 2018).

So far, there have been no researches that are predictive, based on some anthropological parameters, could predict shot velocity, except single one pilot study that determined connection of transversal dimensionality of skeleton and shot velocity (Stamenković et al., 2017). Furthermore, in targeted research to determine the differences between goalball players and those persons with visual impairments who are not involved in sports, flexibility has proven to be a physical fitness option in which these groups differ the most (Çolak et al., 2004). For the above reasons, the aim of this research is to determine the influence of body composition and flexibility on shot velocity in goalball.

METHODS

Subjects

The sample of respondents consisted of 21 goalball players aged 24 to 39, members of five national selections (Serbia, Bosnia and Herzegovina, Montenegro, Sweden, Bulgaria), with at least five years of sports experience on the national and one year on the international level.

Procedure

The sample of the variables was divided into two subunits: body composition and flexibility (predictor set of variables) and the shot velocity (criterion variable). Body composition is analyzed by following variables (Đurašković, 1996): Body height (BH), Body mass (BM), Fat free mass (FF), Viscelar fat (VF) , Body mass index (BMI) and Skeletal muscles mass (SMM). Flexibility is analyzed by following variables (Metikoš et al., 1989): Deep bend on the bench (DBB), Stick exercises (SE), Trunk extension (TE) and Seat and reach test (SRT). The shot velocity (SV) was measured using the RADAR[1]. During the game, SV was read for every shooting attempt, and the highest value was taken for further statistical processing. All testing procedures were performed during 1st International Goalball Tournament “Niš Open 2018“.

Statistical analysis

Statistical data processing was performed in the statistical package SPSS 22. Descriptive statistics have been used-describes the pattern currently in use, and the correlation in which parametric technique (Pirson's correlation) is used in order to determine the correlation between the two variables. A regression analysis was used to analyze the group effects of the predictor variables on the criterion variable.

RESULTS

Table 1. Descriptives statistics of the predictors (body composition and flexibility) and criterion variables (shot velocity).

VARIABLE	Rang	Min	Max	Mean	SD	Skew	Kurt
BH	37,000	157,000	194,000	181,224	8,325	-1,091	2,378
BM	57,500	65,000	122,500	91,200	16,086	0,203	-0,606
FF	33,200	9,600	42,800	24,671	8,281	0,129	-0,076
VF	15,000	2,000	17,000	8,762	3,936	-0,097	-0,001
BMI	17,600	19,700	37,300	28,029	4,781	0,185	-0,259
SMM	31,500	15,100	46,600	35,391	6,631	-1,364	3,655
DBB	43,000	-23,000	20,000	-1,333	13,395	-0,004	-0,553
SE	70,000	36,000	106,000	82,620	22,366	-0,767	-0,245
TE	5,000	25,000	30,000	28,857	2,104	-1,358	-0,136
SRT	56,000	-26,000	30,000	-1,143	14,650	0,370	-0,113
SV	21,000	47,000	68,000	56,238	6,862	-0,027	-1,662

Legend: **BH** – Body height, **BM** – Body mass, **FF** – Fat free mass, **VF** – Viscelar fat , **BMI** – Body mass index, **MM** – Skeletal muscles mass, **DBB** - Deep bend on the bench, **SE** - Stick exercises, **TE** – Trunk extension, **SRT** – Seat and ritch test, **SV** – Shot velocity, **Rang** – Range, **Min** – Minimum, **Max** – Maximum, **Mean** – Mean, **SD** - Standard deviation, **Skew** - Skewness, **Kurt** – Kurtosis.

Table 1. shows the values of descriptive statistics of all predictor and criterion variables. The value of the distribution asymmetry is estimated by Skew, and in the largest number of variables there is a good symmetry and ranges from 0 to ± 0.5 (BM, FF, VF, BMI, DBB, SRT, SV). Also, there are values with acceptable symmetry and ranges in the range of ± 0.5 to± 1.0 or slightly above (BH, SE). The values of asymmetricity of distribution indicating significant asymmetry and moving above ± 1.0 value are present in the three investigated variables (SMM, TE). The value of the distribution homogeneity evaluated by Kurt indicates a large inhomogeneity of the examined sample at 9 out to 11 variables (BM, FF, VF, BMI, DBB, SE, TE, SRT, SV), due the values are negative. There is homogeneity only in the estimated values of 2 variables (BH, SMM).

[1] Pro-Level Speed Training Tool & Radar Gun, Pocket Radar, Inc., 3535 Industrial Dr. Suite A4, Santa Rosa, CA 95403

Table 2. Matrix of intercorrelations of predictors (body composition and flexibility) and criterion variable (shot velocity).

VARIABLE	BH	BM	FF	VF	BMI	SMM	DBB	SE	TE	SRT	SV
BH	1,000	**0,437**	-0,405	0,073	-0,047	0,247	0,348	0,265	0,169	0,315	**0,452**
BM	**0,437**	1,000	**0,504**	**0,893**	**0,842**	-0,062	0,308	0,226	0,171	**0,476**	0,039
FF	-0,405	**0,504**	1,000	**0,638**	**0,701**	**-0,491**	0,142	0,091	-0,048	0,332	**-0,498**
VF	0,073	**0,893**	**0,638**	1,000	**0,913**	-0,127	0,204	0,226	0,080	0,338	-0,085
BMI	-0,047	**0,842**	**0,701**	**0,913**	1,000	-0,166	0,059	0,148	0,111	0,271	-0,129
SMM	0,247	-0,062	**-0,491**	-0,127	-0,166	1,000	-0,118	-0,271	-0,128	-0,191	**0,565**
DBB	0,348	0,308	0,142	0,204	0,059	-0,118	1,000	0,365	-0,323	**0,908**	-0,350
SE	0,265	0,226	0,091	0,226	0,148	-0,271	0,365	1,000	-0,157	0,321	-0,240
TE	0,169	0,171	-0,048	0,080	0,111	-0,128	-0,323	-0,157	1,000	-0,336	0,363
SRT	0,315	**0,476**	0,332	0,338	0,271	-0,191	**0,908**	0,321	-0,336	1,000	-0,432
SV	**0,452**	0,039	**-0,498**	-0,085	-0,129	**0,565**	-0,350	-0,240	0,363	-0,432	1,000

BH – Body height, **BM** – Body mass, **FF** – спољашње масти, **VF** - Висцеларне масти , **BMI** – Body mass index, **MM** – Skeletal muscles mass, **DBB** - Deep bend on the bench, **SE** - Stick exercises, **TE** – Trunk extension, **SRT** – Seat and ritch test, **SV** – Shot velocity.

Table 2. shows the matrix of intercorrelations of predictor variables (body composition and flexibility) and criterion variable (shot velocity). Among the variables that represent anthropometric characteristics there are 13 connections that we can consider as statistically significant. Given the fact that the goal of this paper is the influence of body composition and flexibility on the speed velocity in goalball, the analysis of results will only be directed to the fulfillment of this goal. This matrix shows that only 3 (BH, FF, SMM) of the 11 predictor variables (BH) have a moderate, but significant intercorrelation relationship (BH=0,452, FF=-0,498, SMM=0,565) with the criterion variable SV.

Table 3. shows the results of the regression analysis of the influence of predictor variables (body composition and flexibility) and criterion variable SV (shot velocity). Based on the significance of correlation set-criterion (p=0.040), it can be concluded that there is a statistically significant correlation between the set of predictive variables of the body composition and flexibility on the criterion variable SV. A set of predictive variables of the body composition and flexibility is determined with the criterion variable 76% of the variance (R^2=0,762). The correlation of the selected predictive variables of the body composition and flexibility with the criterion variable (SV) is high (RS=0,873). Specifically, no predictor variable independently has a statistically significant correlation with the criterion variable SV.

Table 3. Regression analysis of influence of predictors (body composition and flexibility) on the criterion variable (shot velocity).

VARIABLE	BETA	PART R	p
BH	1,766	0,544	0,068
BM	-2,56	-0,427	0,166
FF	0,468	0,308	0,330
VF	1,281	0,407	0,189
BMI	0,745	0,325	0,303
SMM	0,379	0,484	0,111
DBB	-0,191	-0,115	0,721
SE	-0,32	-0,416	0,179
TE	0,228	0,318	0,314
SRT	-0,135	-0,071	0,827
RS= 0,873 **R²**= 0,762 **p**=0,040			

BH – Body height, **BM** – Body mass, **FF** – спољашње масти, **VF** - Висцеларне масти , **BMI** – Body mass index, **MM** – Skeletal muscles mass, **DBB** - Deep bend on the bench, **SE** - Stick exercises, **TE** – Trunk extension, **SRT** – Seat and ritch test, **BETA** – standardized coefficient, **PART R** - value of partial correlation, **R** – correlation value, **P** - the significance of correlation with the criterion variable, **RS** – The value of the correlation set-criterion variable, **R²** - Determination coefficient, **p** – The significance of the correlation set-criterion

DISCUSSION

The differences between winners and losers in high level goalball were small in most of the technical skills - it seems that the games are often decided by individual offensive skill executions and individual errors in defense (Lehto et al., 2012), but the shot is the one who finally performs score (Bowerman & Davis, 2012).

The shot in goalball has many variations (Корнев & Правдов, 2018), but only the values of the shot velocity are taken into account, because the modern goalball shots applicable as required by the specific game situations and technique and trajectory did not affect goal rate for men (Link & Weber, 2018). Aditionally, there no significant importance for goalball players selection based on level of vision (Abdullah et al., 2018).

The value of the arithmetic mean SV variable is 56,238 km/h more than modest for the top goalball. Even the highest measured value (68,000 km/h) is not competitive for the top goalball.

The presence of individual statistically significant correlations of the three variables of body composition with the SV varies in the fact that for selection in goalball are needed persons who are of higher growth and body mass than the average population (Scherer et al., 2012).

Furthermore, the importance of the body fat distribution in the defining of the morphological profile of goalball players (Romanov et al., 2017) in compairment with other paralympic athleetes (Lemos et al., 2016).

Values of flexibility of estimated goalball players are higher than sedentary people with visual impairment (Krzak et al., 2015). Higher values of flexibility is the result of continuous training, because of small hereditary factor of that manifestation of fitness (Metikoš et al., 1989).

There is statistically significant correlation between the set of predictive variables of the body composition and flexibility on the criterion variable SV (Table 3.). That means that there is optimal choice of predictive variables, because there are no partial correlations between predictor variables and SV. Combination of used variables of body composition and flexibility should be considered as precondition, but not ultimate prediction for shot velocity in goalball.

CONCLUSION

The aim of this research is to determine the influence of body composition and flexibility on shot velocity in goalball. The sample of respondents consisted of 21 goalball players aged 24 to 39, members of five national selections. The sample of the variables was divided into two subunits: body composition and flexibility (predictor set of 11 variables) and the shot velocity (criterion variable). A regression analysis showed the group effects of the predictor variables body composition and flexibility on the criterion variable CV.

The small number of respondents in this study and the exclusion of other anthropological dimensions in the predictor set of variables are the reason that the conclusions obtained in this study should be accepted with a limitation. However, the associations that have been identified serve as a basis for establishing training objectives, as well as strategies, which favor more effective shot on goal.

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TREND OF THE RESULTS ON PARALYMPIC GAMES AT SWIMMERS WITH INTELLECTUAL IMPAIRMENT

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SUMMARY

The aim of the research was to determine the trend of the development of results at the POG for swimmers with II, of both sexes, and formation of a prediction model for the results of the medal winners at the following POG. Given the fact that, after 2000, there was a ban on the participation of athletes with II at the POG in 2004 and 2008, the prediction model for the results of the medal winners at the POG in Tokyo 2020 could not be developed. Therefore, a descriptive analysis of the trend in the development of the results was made. An increase in the results was observed in both competitions and in all events. The significance of this paper lies in the fact that it can provide an approximate answer to the question posed by the coaches of top-class swimmers with II: what kind of result must a male or female swimmer with II achieve in class S14 in order to win a medal at the next POG?

Keywords: Paralympic games, swimming, intellectual impairment, trend, results.

INTRODUCTION

If they are not physically active, persons with intellectual impairment (II) face many health risks (van Dijk et al., 2017). Regular physical activity of persons with II is essential for achieving normal muscular strength, flexibility, joint stability, and may slow down the reduction in functional abilities that often occur due to impairment (Einarsson et al., 2014). Good health and developed physical abilities and skills are very important for the people of this population, since they are often educated for the professions where this is necessary (Stanković & Aleksandrović, 2013).

Swimmers with II compete at the Paralympic Games (POG) in the S14 class (Swimming classification, 2015). The swimmers from this class perform in the following events in individual competition: 200m freestyle, 100m backstroke, 100m breaststroke, 100m butterfly and 400m medley. Irrespective of the fact that health is the main reason for participation in physical activities, some people with II who have undergone long-term systematized and planned sports training have the imperative of achieving good results and always aim for the highest possible ranks (Hinriksdottir et al., 2014). The coaches of swimmers with II also wish their swimmers to win medals at the largest competitions in the world, such as the POG. Since each of the following POG shows that there is evident progress in the swimming results (Fulton et al., 2009; Veličković et al., 2015), it is necessary for the trainer to be familiar with the "target" result that his champion must be able to swim.

The aim of the research was to determine the trend of the development of results at the POG for the swimmers with II, of both sexes, and the formation of a prediction model for the results of medal winners at the following POG.

METHODS

In order to fulfill the objectives of the research, the primary task was to make a database of the best results – the winners of medals for the previous five POG in the class of swimmers with II, of both sexes. In order to fulfill the research objective, it was defined that, on the basis of the obtained database, a prediction model was made for the results of possible medal winners at POG 2020 in Tokyo. Given the fact that, after 2000, there was a ban on the participation of athletes with II at POG 2004 and 2008[1], it was not possible to render a prediction model for the results of medal winners at POG 2020. For this reason, a descriptive analysis of the trend in the development of the results was made. The results were analyzed in both competitions, i.e. male and female, separately.

RESULTS

Table 1 shows the results of the male swimmers with II who won medals at the POG in the period from 2000 to 2016. The results are presented in the following events: 50m freestyle, 100m freestyle, 200m freestyle, 100m backstroke, 100m breaststroke, 50m butterfly and 200m medley. It should be emphasized that certain events were held only at POG 2000, so this data will not be taken into consideration for the analysis (50m freestyle, 100m freestyle, 50m butterfly). For the 200m freestyle event, there is evident progress in the results of the male swimmers with II at the POG in 2000, as well as at the POG in 2012 and 2016. In terms of the 100m backstroke event, there is also a significant progress in the results at the POG in 2000, as well as at the POG in 2012 and 2016. The 200m medley event was held at the POG in 2000, and then only once more at the POG in 2016, and there was an evident significant progress. The 100m breaststroke is the only event for male swimmers with II where almost identical results achieved for one medal were noted. Namely, at the POG in 2012, this event had to be swum in 66.69s, while this was only 0.02s faster at the POG in 2016. It is noticeable that the results of the gold medal winners at the POG in 2000 are better than the results achieved at the POG in 2012 and 2016.

Table 1. Results of male swimmers with II who won medals at the POG in the period from 2000 to 2016

POG	2000			2004			2008			2012			2016		
Discipline	**G**	**S**	**B**	**G**	**S**	**B**	**G**	**S**	**B**	**G**	**S**	**B**	**G**	**S**	**B**
50m freestyle	25,42	25,96	26,08	BCII	BCII	BCII	BCII	BCII	BCII	N/A	N/A	N/A	N/A	N/A	N/A
100m freestyle	56,60	56,89	57,01	BCII	BCII	BCII	BCII	BCII	BCII	N/A	N/A	N/A	N/A	N/A	N/A
200m freestyle	122,59	124,07	125,66	BCII	BCII	BCII	BCII	BCII	BCII	119,62	119,79	119,93	116,32	116,58	116,69
100m backstroke	63,80	65,14	66,39	BCII	BCII	BCII	BCII	BCII	BCII	61,85	64,44	64,53	59,82	60,63	63,42
100m breaststroke	66,42	76,87	76,99	BCII	BCII	BCII	BCII	BCII	BCII	66,69	68,38	68,43	66,67	66,7	67,64
50m butterfly	27,16	28,41	28,93	BCII	BCII	BCII	BCII	BCII	BCII	N/A	N/A	N/A	N/A	N/A	N/A
200m medley	138,33	142,49	144,42	BCII	BCII	BCII	BCII	BCII	BCII	N/A	N/A	N/A	130,29	132,88	135,46

BCII – ban on the participation of athletes with II by the IPC, N/A – mentioned event was not held, G – gold medal, S – silver medal, B – bronze medal

Table 2 shows the results of the female swimmers with II who won medals at the POG in the period from 2000 to 2016. As with male swimmers, the results are presented in the following events: 50m freestyle, 100m freestyle, 200m freestyle, 50m backstroke, 100m backstroke, 50m breaststroke, 100m breaststroke, 50m butterfly and 200m medley. It should be noted that some events were held only at POG 2000, so this data will not be taken into account for the analysis (50m freestyle, 100m freestyle, 50m backstroke, 50m breaststroke, 50m butterfly). Correspondingly, one event was last held at POG 2000, so the data for this event will not be taken into account (50m backstroke). In terms of the 200m freestyle event, there is evident progress in the results of the female swimmers with II at the POG in 2000, as well as at the POG in 2012 and 2016

[1]At the POG in Athens in 2004, "for the first time in history, a ban was applied on the participation for an athlete with learning disabilities. This rule was introduced after the Paralympics in Sydney, when it was discovered that most of the Spanish national team did not meet the conditions for the competition. The International Paralympic Committee (IPC) determined that exclusions would remain in force until specific tests for determining fitness were introduced. Otherwise, basketball and tennis matches were organized for athletes with learning disabilities, while the Special Olympics remained the main competition for this category of disability." (Milenković & Živanović, 2010, pp. 57-58). In conjunction with the International Sports Federation for Persons with Intellectual Impairment, in 2009, the IPC published a joint statement on the reintegration of athletes with intellectual impairment at the next POG 2012 in London (INAS-FID, 2009).

For the 100m backstroke event, there is also evident progress in the results between POG 2012 and 2016 (this event was not held at POG 2000). The same is valid for 100m breaststroke. For female swimmers with II, the 200m medley event was held at the POG in 2000, and then only once more in 2016, and there is evident progress of nearly 14 seconds for winning the gold medal.

Table 2. Results of male swimmers with II who won medals at the POG in the period from 2000 to 2016

POG	2000			2004			2008			2012			2016		
Discipline	G	S	B	G	S	B	G	S	B	G	S	B	G	S	B
50m freestyle	29,13	29,37	29,55	BCII	BCII	BCII	BCII	BCII	BCII	N/A	N/A	N/A	N/A	N/A	N/A
100m freestyle	63,35	64,92	65,10	BCII	BCII	BCII	BCII	BCII	BCII	N/A	N/A	N/A	N/A	N/A	N/A
200m freestyle	134,90	135,97	140,64	BCII	BCII	BCII	BCII	BCII	BCII	132,63	133,18	134,80	123,30	126,92	130,20
50m backstroke	32,56	33,93	34,02	BCII	BCII	BCII	BCII	BCII	BCII	N/A	N/A	N/A	N/A	N/A	N/A
100m backstroke	HO	HO	HO	BCII	BCII	BCII	BCII	BCII	BCII	68,93	69,46	69,5	64,05	66,33	68,67
50m breaststroke	37,11	37,15	38,17	BCII	BCII	BCII	BCII	BCII	BCII	N/A	N/A	N/A	N/A	N/A	N/A
100m breaststroke	HO	HO	HO	BCII	BCII	BCII	BCII	BCII	BCII	76,85	80,64	81,21	72,62	72,89	77,35
50m butterfly	31,05	31,06	32,65	BCII	BCII	BCII	BCII	BCII	BCII	N/A	N/A	N/A	N/A	N/A	N/A
200m medley	153,44	155,59	158,53	BCII	BCII	BCII	BCII	BCII	BCII	N/A	N/A	N/A	139,60	147,58	149,49

BCII – ban on the participation of athletes with II by the IPC, N/A – mentioned event was not held, G – gold medal, S – silver medal, B – bronze medal

DISCUSSION

In Paralympic swimming, only male and female swimmers with II who are highly functional and moderately below the average intelligence quotient appear (DePauw & Gavron, 2005). However, in spite of the lack of morphological differences, research has shown that there are differences between swimmers with II and swimmers without II, and they are related to strength, (Van de Vliet et al., 2006), explosive force and cardiovascular fitness (Daly et al., 2006). When it comes to indicators of a swimming event, swimmers with II show lower numerical indicators of actions related to start or turn. They also have a shorter swim step and an unstable frequency of strokes, which has not been explained so far (Einarsson, 2009). Differences in motor abilities can be sought even in the pre-pubertal age in which girls and boys have low levels of participation in physical activities (Einarsson et al., 2015). The increase in the results achieved by swimmers with II from POG 2000 to POG 2016 supports the fact that the selection of swimmers with disabilities, as well as training, has progressed steadily. The occurrence of weaker progression of the achieved results of the medal winners among the swimmers with II in the 100m breaststroke event can be explained primarily by the limitation of the swimmers with II to achieve moderately complex movements in this style. Earlier research has shown that, especially in this event, swimmers with II display very low values in the race indicators related to the start and turn (Daly & Martens, 2011).

With female swimmers who have II, there is great progress in the 200m freestyle event between the last two POG. In particular, the female gold medalist at POG 2016 swam almost 10s faster than the medal winner at the previous POG 2012 (the improvement from POG 2000 was slight). It was probably the specialization of female swimmers with II within one event, where progress could be made, that led to such great progress (DePauw & Gavron, 2005). There was a difference in the swimming results achieved by the female gold medal winners in the 200m medley event between POG 2000 and 2016 (this event was not held at POG 2012). Owing to the length of time for swimming this distance, the focus was probably on recovery, of course, in addition to the excellent strategic selection and conducted training.

There were also notable differences between the sexes. Male swimmers were always faster than female swimmers with II. This is in line with the research that has shown that other race indicators (start, turns, finish) are better for male swimmers with II than for female swimmers with II in class S14 (Malone & Schiltz, 2001). However, in some events (200m freestyle, 200m medley), the realized results of the female swimmers with II at the POG in 2016 were at the level of the results of the male swimmers with II at the POG in 2000. It is assumed that the experience in selection and training with the male swimmers with II at the “turn of the century” was also used in the work with the female swimmers who have II.

CONCLUSION

Considering the fact that, after 2000, there was a ban on the participation of athletes with II (at POG 2004 and 2008), it was not possible to produce a prediction model of the results of medal winners at POG 2020. Therefore, a descriptive analysis was undertaken of the trend in the development of results. The results were analyzed for both sexes, male and female, separately. In both competitions, the results were improved at three time points in the 200m freestyle event (POG 2000, 2012 and 2016). In the men's competition, the improvement in the results was achieved at three time points in the 100 m backstroke event (POG 2000, 2012 and 2016). On the other hand, in the women's competition, the results in this event improved between the last two held POG. In the men's competition, improvements in results were not achieved at three time points in the 100m breaststroke event (POG 2000, 2012 and 2016). On the other hand, in the women's competition, there was an improved result in this event between the last two held POG. In both competitions, the improvements in results were achieved at two time points in the 200m medley event (POG 2000 and 2016).

This paper is limited by the fact that, owing to the non-participation of swimmers with II at the POG held in 2004 and 2008, it was not possible to calculate the trend of the development of results and the prediction of the results necessary to win a medal at the next POG in Tokyo 2020. However, a descriptive analysis was performed of the trend of the development of the results from the POG in Sydney in 2000, so certain conclusions were drawn. In general, the training of athletes with II is highly complex, primarily due to the characteristics of this type of disability. On the other hand, it is a challenge for athletes with II, as well as for the coaching staff, to do their best to achieve adequate results. The significance of this paper lies in the fact that it can provide an approximate answer to the question of the coaches of top-class swimmers with II, i.e. what kind of result must a male or female swimmer with II achieve in class S14 in order to win a medal at the next POG?

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CRITERIA FOR SPORT SELECTION OF 11-12-YEAR-OLD CYCLISTS

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SUMMARY

For achieving high performance sport results is needed good knowledge and understanding of anatomy and physiology functional characteristics of adolescents, which will help ensuring the use of optimal training methods and help individual sport realization. The establishment of regularities in dynamics of individual indexes, depending on age of young cyclists is of great importance for sport training and sport result prediction as a function of dynamic relation between morphological, motor and technical abilities. The results from the following study may be used to update the training process in cycling by specifying and individualization of training parameters.

Keywords: cycling, result, test, revealing, research.

INTRODUCTION

Cycling is a sport that has always been in the limelight of spectators, athletes and sport specialist attention due to its attractiveness. It is also sport with traditions and successes in Bulgaria. Cycling brings demands on the athletes and his body, that is widely applied among people of different age groups and professions as a mean of physical development and mental relaxation. Doičev (1982).

Ascending level of sport performance in cycling as well as the huge competition struggle for hegemony in this sport requires continuous improvement of training process effectiveness and quality. Borukova (2013). The development of growing human organism is of interest to scientists and researchers not only in sport, but from biological point of view. Control studies and measurements at the stage of initial sport training are excellent means for sport talent detection. Gloševa, Crov, & Corova (1990).

Unfortunately, in Bulgaria there is still no established methodology for objective measuring, systematization, reasoning and statistical reliability of specialized set of tests for sport selection and orientation of young cyclists. Kolev & Ilinova (2006), Kolev (2012), Kolev (2012).

The aim of the following study is to establish statistically reliable criteria o activities for sport selection of cyclists in the age period 11-12-year-old.

METHODS

Reaching highest levels of sport mastery is impossible mission without the joint effort of numerous sport specialists – medical staff, pedagogues, psychologists, etc. – including scouts who will have to find gifted children and develop their talent through the years Corov (2001), Corova, (2013).

The study was conducted in the period 2016-2018. Subject of the study is the system for sport selection and orientation, as well as the initial training process of young cyclists.

Object of the study is the physical development, level of physical preparedness, technical and tactical abilities of young cyclists from the Republic of Bulgaria.

Respondents of the study are 20 boys, training cycling in clubs in Bulgaria in the age period 11-12-year-old.

The tests included in the study appear to be significant for both for physical development and level of preparedness, and the evaluation of achievements during development of young cyclists. Kolev & Ilinova (2006). Test battery includes 14 tests (indexes), bringing information on anthropometric characteristics and motor abilities of the respondents.

The obtained results are subject to mathematical and statistical processing using variance analysis and correlation analysis.

RESULTS

Table 1 presents the average values and variance analysis results of criteria for sport selection of 11-12-year-old cyclists during the first testing.

Table 1. Variance analysis of 11-12-year-old cyclists – first testing.

index	measured in:	R	min	max	X	m_x	S	V%
30 m crouch start	sec.	0,86	5	5,86	5,27	0,06	0,27	5
30 m standing start	sec.	0,48	4	4,48	4,16	0,03	0,13	3
100 m flying start	sec.	2,01	6,68	8,69	7,81	0,15	0,66	8,5
200 m flying start	sec.	3,8	13,04	16,84	15,11	0,26	1,19	7,9
500 m start from place	sec.	10,5	37,38	47,84	43,35	0,7	3,16	7,3
1000 m start from place	sec.	10,2	83,02	93,22	85,87	0,62	2,81	2,53
2000 m start from place	sec.	4,05	176,13	180,18	177,92	0,27	1,21	0,68
Dynamometry - strong hand	kg	8	24	32	27,45	0,45	2,23	8,12
Dynamometry - weak hand	kg	10	21	31	26,05	0,57	2,56	9,78
Flexibility	cm	5	4	9	6,7	0,31	1,42	21
Height	m	16	137	153	145,07	1,09	4,87	3,55
Standing long jump	m	0,49	1,64	2,13	1,95	0,03	0,15	8
Weight	kg	8,6	40	48,6	45,15	0,65	2,93	6,5
Vertical jump	cm	9	28	37	32,29	0,55	2,46	7,61

The test 500 m start from place presents the capabilities of the cyclist in most specific and comprehensive way regarding his performance in the chosen competition discipline and brings objective information about his sport-technical abilities. It has average value of 43.35±0.71 sec. and variance coefficient V%=7.30. The low level of variance coefficient similar sport-technical abilities among respondents – young 11-12-year-old cyclists. Its place in the set of tests is important and shows the genetic prerequisites for speed-strength abilities of cyclists.

Cyclists special speed abilities are measured using 100 and 200 m riding from flying start and respectively it has average value of 7.81±0.50 sec. and 15.11±0.27 sec. – it is fundamental expression of basic cyclists' quality, starting acceleration and maximum speed predispose. The variance coefficients range between 7-9%, and reveal high level of uniformity among respondents. The quick start and ability to reach maximum speed (Vmax) are essential factor of sport performance in cycling.

Particularly important are the tests 1000 m and 2000 m starting from place for assessment of speed-strength endurance of young cyclists. They have average values of 85.87 ±0.62 sec. for the first test, and 177.92 ±0.27 sec. Here we find lover variance coefficient values – respectively V=2.53% and V=0.68%. Their inclusion in the test battery for selection is determined by the fact that in cycling the endurance is anaerobic-aerobic energetic levels – similar to the tests.

Indexes presenting cyclists lower limbs explosive abilities are 30 m from crouch start and 30 m from flying start with average values of 5.27 ±0.62 sec. and 4.16 ±0.31 sec. for the second test. Variance coefficient show high homogeneity of the sample – V=5.00% for 30 m from crouch start and V=3.29% for 30 m flying start. Their place in the test set is connected with the abilities for quick start reaction, which, according to many authors, is genetically determined.

Speed-strength abilities of the lower limbs are measured using two tests – standing long jump and vertical jump – also important component of the sport talent. The average values respectively are 1.95 ±0.33 m for the first test and 32.29 ±0.55 cm for the second. The combination of speed-strength abilities is extremely important for cycling. Variance coefficient range between 6-7% for the to two tests and shows high level of uniformity.

Isometric strength of upper limbs (right and left hand strength) carry information regarding the ability of cyclists effortlessly to contact with the bicycle. Average values respectively are 27.45 ±0.45 kg and 26.05 ±0.57 kg. Here we also find high level of uniformity using the variance coefficient – values range between 8-9%. These indexes appear to be in a key place in the system for sport selection because they are test measuring the riding technique in cycling sport.

Flexibility index has average value of 6.7 ±0.31 cm and logically the highest variance coefficient values – V=21%. It determines the ability for quick mastering the art of pedaling and standing on the bicycle – key element in cycling sport.

The two measured anthropometric indexes – height and weight – are important for sport selection and orientation of athletes cycling sport and discipline. Corova, P., Miladinov, O., & Kolev, I. (2012). For example, height is important for athletes in the sprint events and individual pursuit, while lower height levels are more suitable for climbers. These signs have average value of 145.07±1.09 cm for height and 45.15±0.65 kg for weight – variance coefficient are respectively V=3.55% and V=6.5% and define high homogeneity of respondents group of 11-12-year-old cyclists.

To confirm the statistical reliability of the test battery for selection in this age group we conducted a second testing. The results from variance analysis of the second testing are presented in Table 2, and from correlation analysis – on Table 3.

In the spirit of correctness, it is necessary to note here that we did not apply comparative Student-T test. The reason for this is the fact that kurtosis and skewness values are high and test sample is limited with only 20 cyclists aged 11-12-year.

Table 2. Variance analysis of 11-12-year-old cyclists – second testing.

index	measured in:	R	min	max	X	m_x	S	V%
30 m crouch start	sec.	0,66	4,94	5,60	5,17	0,04	0,21	4,10
30 m standing start	sec.	0,62	3,99	4,61	4,12	0,04	0,16	4,10
100 m flying start	sec.	2,36	6,04	8,40	7,49	0,15	0,66	8,81
200 m flying start	sec.	3,94	12,90	16,84	14,80	0,25	1,12	7,6
500 m start from place	sec.	8,51	37,40	45,91	42,29	0,56	2,55	6,00
1000 m start from place	sec.	8,75	81,68	90,43	84,14	0,54	2,44	2,89
2000 m start from place	sec.	6,21	173,12	179,33	175,60	0,34	1,54	0,87
Dynamometry - strong hand	kg	10,00	26,00	36,00	29,41	0,62	2,79	9,48
Dynamometry - weak hand	kg	10,00	23,00	33,00	27,60	0,60	2,72	9,85
Flexibility	cm	5,00	5,00	10,00	8,00	0,30	1,37	14,25
Height	m	15,00	141,00	156,00	149,20	1,02	4,60	3,07
Standing long jump	m	0,49	1,72	2,21	2,01	0,03	0,14	7,06
Weight	kg	15,00	43,00	58,00	48,32	0,85	3,80	7,86
Vertical jump	cm	8,00	31,00	39,00	35,18	0,53	2,41	6,85

In the test 100 m and 200 m from flying start average value from the second testing are respectively 7.49±0.66 sec. and 14.80±1.12 sec. Here variance coefficients range between 7-8%. Correlation coefficients are respectively rtt=0.58% at α≤0.04 and rtt=0.89 at α≤0,00. The first index has moderate reliability, while the second one – high level of reliability.

During the second testing in indexes 100 m and 200 m from flying start we find average values of 7.49±0.66 sec. and 14.80±1.12 sec. Here, the variance coefficient maintains in the range of 7-8%. The correlation coefficients are respectively rtt=0.58 when α≤0.04 and rtt=0.89 when α≤0.00. The first index has moderate reliability, while the second has high level of reliability and can be used as main criteria for sport selection bringing information regarding levels of maximum speed over short distances. This gives us reason to estimate the coefficients of uncertainty – k2-77% (low reliability) and k2=21% (high reliability).

The average value of 500 m starting from place test (second testing) is 42.29±2.55 sec. The variance coefficient is 6% and brings information for the high degree of homogeneity of tested sample. The correlation coefficient for test-retest is high – rtt=0.98 when α≤0.00 and this test shows high level of statistical reliability and is included in the test battery for sport selection and orientation of young cyclists. It has a low level of the uncertainty coefficient – k2=4% (high reliability level).

For the tests 1000 m and 2000 m starting from place has average values from the second study respectively 84.14±2.44 sec. and 175.60±1.54 sec. The variance coefficient for both indexes maintained in the range of 2%. Correlation coefficients are respectively rtt=0.87 when α≤0.00 and rtt=0.32 when α≤0.16. The first index is highly informative and reliable, while with the second we find low reliability levels and it should be removed from the test battery. Reason for the last is the that 2000 m starting from place is combination of speed-strength abilities and requires high level of physical preparedness which young cyclists in this age (11-12-years) do not possess. This fact is confirmed by the uncertainty factors – k2=25% and k2=95% (for 2000 m this means low reliability level).

Table 3. Statistical reliability of indexes included in the test battery for 11-12-year-old cyclists.

index	measured in:	r_{tt}	α ≤ 0,01	$κ^2$ (%)
30 m crouch start	sec.	0.53	0.06	72
30 m standing start	sec.	0.48	0.02	77
100 m flying start	sec.	0.58	0.04	77
200 m flying start	sec.	0.89	0.00	21
500 m start from place	sec.	0.98	0.00	4
1000 m start from place	sec.	0.87	0.00	25
2000 m start from place	sec.	0.23	0.16	95
Dynamometry - strong hand	kg	0.96	0.00	8
Dynamometry - weak hand	kg	0.94	0.00	12
Flexibility	cm	0.16	0.30	98
Height	m	0.97	0.00	4
Standing long jump	m	0.97	0.00	4
Weight	kg	0.82	0.00	33
Vertical jump	cm	0.92	0.00	16

The average values of isometric strength of upper limbs (right and left hand) are respectively 29.41±2.79 kg and 27.60±2.72 kg. The variance coefficients are within 10% and have statistical reliability – rtt=0.96 when α≤0.00 and rtt=0.97 when α≤0.00. Therefore, quite rightly they are included in the system for sport selection of young cyclists. Coefficient of uncertainty are k2=8% and k2=12%.

Flexibility test, respectively, with the lowest statistical reliability rtt=0.16 with α≤0.30 and coefficient of uncertainty 98%. The place of flexibility test in the test battery is particularly delicate and need to pre-considered their application and verify their authenticity.

The standing long jump and vertical jump tests have high degree of statistical reliability – rtt=0.97 when α≤0.00 and rtt=0.92 when α≤0.00 and coefficients of uncertainty 4% and 16%.

Both anthropometric indexes – height and weight – are tests with great importance for sport selection and orientation in cycling. With these indexes the levels of uncertainty are 4% and 33% (rtt=0.96 when α≤0.00 and rtt=0.82 when α≤0.00) and show high level of statistical reliability.

Analyzed above results give us the reason to state that the obtained information regarding statistical reliability of test included in the test battery for 11-12-yer-old cyclists is correct, therefore, selected tests are relatively appropriate. Exceptions are the tests that carry information about the physical ability flexibility, starting reaction and maxim speed in the first meters from the start.

CONCLUSION

Analysis of experimental data has shown that the specification of the selected tests and respondents age determine the statistical significance and level of reproducibility.

Greater results stability we find in the tests for isometric strength of upper limbs (strength of right and left hand) and 500 m starting from place. Follow the tests presenting speed-strength abilities of lower limbs in the horizontal and vertical planes – standing long jump and vertical jump.

The results from the following study may be used to update the training process in cycling by specifying and individualization of training parameters.

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FREQUENCY AND TYPE OF PENALTIES AWARDED IN COMBATS CONDUCTED BY WORLD TOP JUDOKAS

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SUMMARY

High level judo is demanding combat sports which, beside excellent physical condition, requires high level of technical and tactical skills. Coaches point out technical and tactical preparation as a most important for achieving a success in competition. There are a lot of performance analysis research with technique and tactic as a main subject. Still, very few of them deals with the topic of penalties which are an important tactical tool of the judokas. Aim of this research is to analyze frequency and type of penalties awarded in combats conducted by World top judokas. The research sample consisted of 132 fights from most important judo competitions held in 2018. Criteria for including the fight in the sample was that one of the competitors is one of the TOP 10 ranked judokas on the IJF's World ranking list in the under 90kg category. Observational instrument for registration of unsuccessful attacks, successful attacks and penalties was created for the purpose of the study. We registered 792 actions, from which 311 or 39% were penalties. Infringement of the rules upon which referee decided to award a penalty to one of the competitors were as follows: passivity (49%), bad kumikata (20%), false attack (16%), blocking attitude (6%), stepping out of the contest area (5%), and other (4%). Chi-square test showed that there is no significant difference between frequencies of enforced penalties between World best judokas (Top 10) and their opponents, lower ranked judokas in the under 90kg category ($p>0.05$). Results has shown that penalties are the important part of the judo match and that they are used, as a tactical tool, in the same way by all high level judokas. As a coaching advice we can recommend to athletes to try to avoid three most frequent rule infringement: being passive, establish a bad kumikata and conducting a false attack.

Keywords: rule infringement, tactical preparation, penalty.

INTRODUCTION

Judo is a combat sport that emerged from Japan's traditional martial art jujutsu. Dr Jigoro Kano, the founder of judo, transformed the method that was used for closed combat by samurai warriors, making it more interesting for the civil society. From the beginning, he planned to establish a form of physical education that can be practiced by anyone, regardless of status, age, or any other mean. As a first member of International Olympic Committee from Asia, Kano realized the power of sport movement and shifted his martial arts toward sport by making it safe for all the practitioners and by establishing clear fighting rules (Bratić, Nurkić, Cicović, 2014). Modern judo of the 21st century is combat sport which is characterized by spectacular throwing techniques mixed with brilliant ground fighting sequences. Rules of sport divide competitors by age and weight. The ideal "perfect technique will always win" was abounded and competitors are now given equal chances by including the weight divisions. There are seven weight categories for man and equal number for women. For men there are: under 60kg, form 60kg to 66kg, from 66kg to 73kg, from 73kg to 81kg, from 81kg to 90kg, from 90kg to 100kg and above 100kg.

Researchers have shown that there are different factors that influence technical and tactical arrangements during a judo fight. For example expertise (Calmet and Ahmaidi, 2004), competitive outcome (Escobar-Molina et al., 2014) or weight categories (Courel et al. 2014). Winning athletes have shown to attempt more effective attacks than losing athletes after being penalized (Escobar-Molina et al., 2014). Consequently, it is recommended that notational analysis in judo should be conducted with consideration for penalties because with the latest rule changes we have higher percentage of penalties during the combat (Franchini, Takito, Calmet, 2013; Calmet et al. 2017). When we investigate penalties we need to take into consideration that there is a gender difference (Franchini et al., 2008) and also a difference between different weight categories, since it is documented that in the heaviest categories higher percentage of penalties was detected (Pujszo, Adam, Kuźmińska, Błach, 2014).

Aim of this research is to analyze frequency and type of penalties awarded in combats conducted by world top judokas in the under 90kg category.

METHODS

Subjects

Sample was consisted of 132 fights from the under 90kg category. Criteria for including the fight in the sample where as follows:

- Fight was conducted on the one of the major tournaments (Continental Championship, Masters, Grand Slam, and Grand Prix).
- Fight was conducted in 2018.
- One of the competitors was the TOP 10 ranked judoka on the IJF's World ranking list in the under 90kg category (downloaded on 27.08.2018)

Procedure

All combats were downloaded from Dartfish.tv - platform for viewing and sharing of video materials. International Judo Federation and European Judo Union have their official channels on the platform where one can freely download the videos from the competitions organized by IJF and EJU.

Combats where analyzed in Lince software. Lince is digital software for sport performance analysis (Gabín, Camerino, Anguera & Castañer, 2012). Observational instrument was created for the purpose of the study. Following actions were registered: unsuccessful attacks, successful attacks (wazari, ippon), penalties (type: passivity, blocking attitude, stepping out of the contest area, bad kumikata, false attack, and other reasons).

Statistical analysis

Percentage was used for presenting the general data about the fights conducted (number of attacks, scores, penalties, etc.). For testing the difference between frequencies of awarded penalties Chi-square analysis was conducted.

RESULTS

Table 1 Total actions conducted

Scores	Unsuccessful attacks	Penalties	Total
143 (18%)	338 (43%)	311 (39%)	792

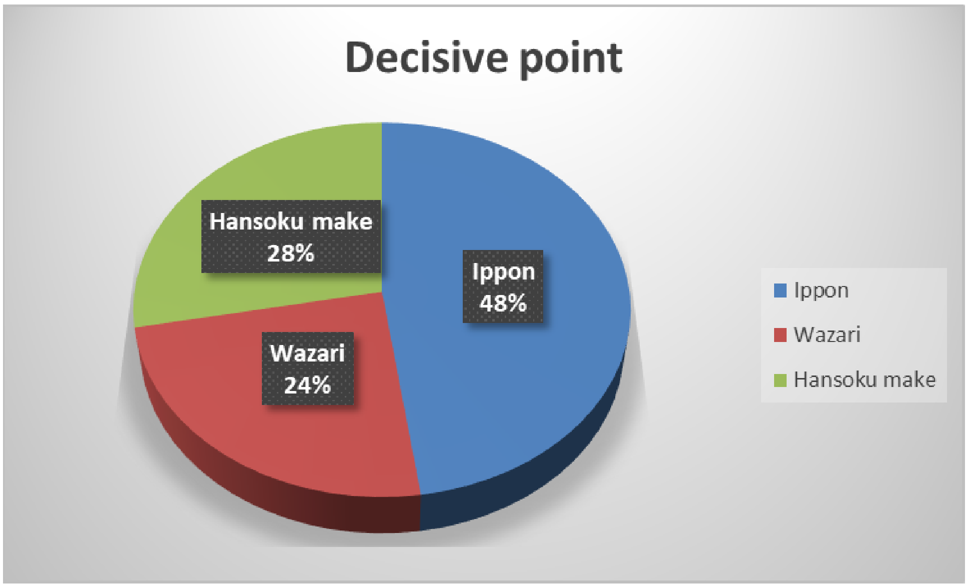
In 132 analyzed combats total of 792 observed parameters were detected. There were 481 attacks and 311 penalties. Attacks included 143 scores and 338 unsuccessful attacks (table 1).

Almost half of the fights (63) ended with best possible outcome – Ippon for one of the competitors. 32 fights were decided by scoring the technical point Wazari. There were 37 fights with the most unwanted outcome, finishing with third penalty and Hansoku make (disqualification) for one of the judokas. Neither one direct disqualification was registered. Picture 1 is showing the percentage of decisive points in the analyzed combats.

In the picture 2 attacking ratio was presented – percentage of successful and unsuccessful attacks, as well as percentage of Ippon and Wazari scored. From these data we can extract that effectiveness of attacks was 0.3. (Effectiveness of attacks – a proportion of the number of attacks, for which points were granted, to the number of attacks made – Boguszewski, 2014).

Large share of the sample were penalties (311). In table 2 you can see number and type of penalties awarded during the fights. Best judokas have enforced 188 penalties to their opponents (1.4 per match), while in the same time receiving 123 (0.9 per match). That means that Top 10 judokas had a tactical advantage during the fight. Most of the penalties was awarded for passivity (non combativity) 49%, followed by mistakes in kumikata - 20% and false attack attempts - 16 %.

We used nonparametric Chi-square test to determine is there a significant difference between frequencies of penalties awarded to Top 10 judokas and their opponents (table 3). We wanted to see is there a difference in tactical approach by comparing the type of penalties awarded.



Picture 1 Decisive points

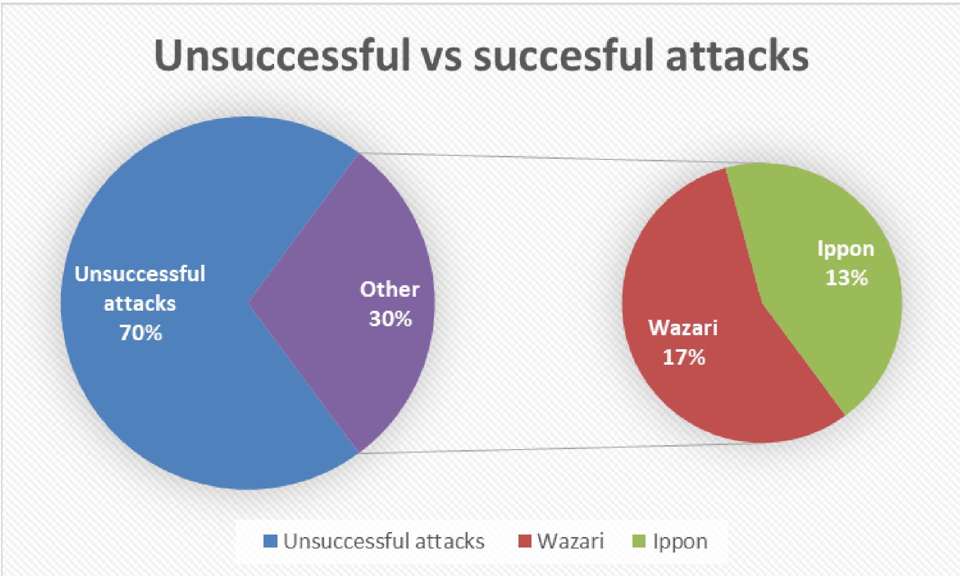


Table 2 Total number and type of penalties awarded in the analyzed combats

Passivity	Blocking	Stepping out	Bad kumikata	False attack	Other reasons	Total
151 (49%)	19 (6%)	15 (5%)	63 (20%)	49 (16%)	14 (4%)	311

Table 3. $\chi2$ Calculations Two-way Contingency Table

	Difference in enforced penalties between top 10 and other judokas						
	Passivity	**Block**	**Stepping out**	**Bad kumikata**	**False attack**	**Other reasons**	
Top 10	86	10	8	40	35	9	**188**
Opponents	65	9	7	23	14	5	**123**
	151	**19**	**15**	**63**	**49**	**14**	**311**

$\chi2 = 4.376$, $df = 5$, $\chi2/df = 0.88$, $P(\chi2 > 4.376) = 0.4967$

Chi-square analysis showed that there is no significant difference between frequencies of enforced penalties between world best judokas (Top 10) and their opponents, lower ranked judokas (p>0.05).

DISCUSSION

General data shows us a big percentage of penalties in the sample (39%), with only 18% of successful attacks that ended with a score for one of the competitors, Little bit more encouraging is the share of decisive points (points that decided the match outcome). 48% of the fights was won by scoring an Ippon, meaning in the best possible way. These results are better compared to results obtained at London Olympic Games where percentage of Ippons was 42.9%, but still slightly worse than results at Beijing Olympics where percentage of Ippons was 51.3% (Nakamura, 2012).

With attack effectiveness of 0.3, our results are equal to results obtained by Boguszewski, 2014. It is important to highlight that his sample also included combats of World best judokas. It was made of the final combats of major tournaments held between 2007 and 2010, including gold medal combats from the Beijing Olympic Games, the World Championships in Tokyo (2010) and in Rotterdam (2009), the Grand Slam in Paris (2010), and the World Cups in Warsaw (2007 and 2009).

One of the first performance analysis research (Sikorski, Mickiewicz, Majle & Laksa, 1987) state that most important tactical skill is ability to enforce a penalty to your opponent. Judo rules changed significantly afterwards, but the importance of this ability remains. This is confirmed by the fact that winning odds rise with every penalty enforced upon your opponent (Escobar-Molina et al., 2014). Thus it is logical that judokas use their tactical skills to obtain advantage via penalties.

When we compared difference between frequencies of enforced penalties between top 10 and their opponents, we found no significance ($p>0.05$). These results suggest that World best judokas and lower ranked judokas use same tactical approach to gain advantage via penalties, only elite judokas do it slightly better (they provoke 0.5 more penalties than they receive). They try to be dominant and attack often (most of the penalties are awarded for passivity). By having a dominant position and grip they provoke opponents to make mistakes in kumikata or to make false attack attempts.

CONCLUSION

Performance anlysis in judo usually address technical and tactical skills of the judokas. Tactics include offensive, defensive actions, but they also include prohibited actions that resulted with a penalty for one of the competitors. Results has shown that penalties are the important part of the judo match and that they are used, as a tactical tool, in the same way by all high level judokas. As a coaching advice we can recommend to athletes to try to avoid three most frequent rule infringement: being passive, establish a bad kumikata and conducting a false attack.

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DIFFERENCES IN THE EXPLOSIVE STRENGTH OF LOWER LIMBS DURING THE PERFORMANCE OF BASKETBALL JUMP SHOTS

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SUMMARY

The aim of this study was to determine the difference in explosive strength of lower limbs during the performance of basketball jump shots by youth basketball players. Participants were 64 basketball players, divided into two groups, experimental with 32 players (age 15.41 ± 0.33), and control with 32 players (age 15.9 ± 0.11). For determining the differences between groups on initial and on final measurement t-test for independent samples was used. The results showed that on the initial measurement there was a difference between the two variables and that on final measurement, after 10 weeks of the training program, there was the difference in eight variables.

Keywords: Vertical jump, Basketball, OptoJump, youth.

INTRODUCTION

According to Varghesea & Shelvam (2014), a proper jump shot is the most important technique in a basketball game. For performing an effective jump shot, biomechanical parameters and balance of the body are playing an important role (Millslagle, 2002; Button et al., 2003; Okubo & Hubbard, 2006; Fontanella, 2007; Lam et al., 2009). This is the most known technique (Chen, Lo, Lee, Wang, & Shiang, 2005) as well as the most important and most common one (Hess, 1980; Çetin & Muratl, 2014).

There are many factors that can determine the outcome of the jump shot. One of them is certainly the height of the vertical jump. With higher vertical jump it is much easier to release the ball over the defender and it’s harder to block that kind of shot. For performing such a jump, player needs to have a high level of physical fitness (Oudejans, Karamat, & Stolk, 2012; Struzik, Pietraszewski, & Zawadzki, 2014) in other words, high level of lower limbs explosive strength. The lower limbs of the shooter are playing a big role in performing a precise jump shot. They should provide a good balance and need to have a high level of explosive strength (Krause, Meyer, & Meyer, 2008; Chen, Lo, Lee, Wang, & Shiang, 2005).

At the movements such as takeoff and landing, during the vertical jump, explosive strength is necessary (Bubanj, Bubanj, Stanković, & Đorđević, 2010). Explosive strength allows athletes to accelerate their body, or part of the body to a certain point. In a basketball game, it can be seen all the time because the players are using it in both offense and defense.

METHODS

Subjects

There were 64 healthy basketball players divided into two groups who participated in the research. One of the groups was experimental with 32 basketball players (age 15.41 ± 0.33), who trained according to a training program for 10 weeks. The second group controlled with 32 basketball players (age 15.9 ± 0.11) who trained according to their coach's program.

Procedure

The Initial measurement was done one week before the start of the program and the final measurement was done a week after the end of the program. OptoJupm was used for measuring the variables of explosive strength of lower limbs. The following variables were used to estimate explosive straight: FLT – Flight time of the jump shot (s); HIG – Height of the jump shot (cm); POW – Power of the jump shot (W/kg); FOR – Force of the jump shot (N/kg) and SPE – Speed of the jump shot (cm/s).

Each player performs a jump shot from the left and right wing and from a position against the basket. After making three shots player moved to the next position. Those three made shots, form each position, are used for further analysis. Shooting positions were set at distance of five meters (two points) and 6.75 m (three points).

Training Program

The program lasted for 10 weeks, three practices a week with one (24h) or two days (48h) for recovery. Duration of each practice was 90 minutes with introductory, preparatory, main and final part of the practice. The program was a combination of plyometric and shooting exercise. The introductory part of the practice had a purpose of preparing the body for the main part with warm-up exercises. In the preparatory part of practice, the players were introduced to the training goal of that day. In the main part, players carried out appropriate exercises, planned for that practice. The final part of the training was used for relaxation and recovery of the muscles. The plyometric program had six levels of exercise load intensity, from lower to higher, depending on a week. The shooting part of the program consisted of shooting exercises, tasks and mutual competitions with different levels of difficulties also depending on a week. The level of difficulties was reflected by bringing the exercises into realistic conditions. The training program with exercises and dosing can be found in Radnković, Bubanj, Berić, Stanković, & Stojić, (2018).

Statistical analysis

Data for the made shots from each position were used for statistical analysis (three made shots from three positions, from both distance). The difference between groups on initial and on final measurement was determined using the t-test.

RESULTS

Table 1: Descriptive statistic for control (CG) and experimental (EG) group on initial and final measurement

ID		N	INITIAL		FINAL	
			Mean	Std. Dev.	Mean	Std. Dev.
FLT2p	CG	288	0.27	0.08	0.27	0.09
	EG	288	0.26	0.08	0.32	0.05
FLT3p	CG	288	0.32	0.07	0.33	0.08
	EG	288	0.32	0.07	0.38	0.04
HIG2p	CG	288	9.71	5.27	9.83	5.38
	EG	288	9.27	4.94	15.45	4.07
HIG3p	CG	288	13.53	5.41	13.82	5.74
	EG	288	13.34	4.86	21.31	4.39
POW2p	CG	288	7.09	2.54	7.05	2.35
	EG	288	6.74	2.21	8.52	1.54
POW3p	CG	288	8.54	2.22	8.69	2.32
	EG	288	8.35	1.89	10.65	1.49
FOR2p	CG	288	0.44	0.17	0.44	0.15
	EG	288	0.43	0.14	0.44	0.09
FOR3p	CG	288	0.57	0.18	0.59	0.19
	EG	288	0.58	0.14	0.61	0.10
SPE2p	CG	288	16.38	2.29	16.29	2.38
	EG	288	15.95	2.03	19.49	2.30
SPE3p	CG	288	15.30	2.76	15.15	2.52
	EG	288	14.62	1.99	17.79	2.08

Table 2: Difference between groups on initial measurement.

INITIAL		F	Sig.	t	df	Sig. (2-tailed)	Mean Dif.	Std. Err. Dif.	Low	Up
FLT2p	Equal variances assumed	0.30	0.58	1.08	547.00	0.28	0.01	0.01	-0.01	0.02
	Equal variances not assumed			1.08	543.47	0.28	0.01	0.01	-0.01	0.02
FLT3p	Equal variances assumed	1.41	0.23	0.48	547.00	0.63	0.00	0.01	-0.01	0.01
	Equal variances not assumed			0.48	540.58	0.63	0.00	0.01	-0.01	0.01
HIG2p	Equal variances assumed	1.40	0.24	1.01	547.00	0.31	0.44	0.44	-0.41	1.30
	Equal variances not assumed			1.01	541.84	0.31	0.44	0.44	-0.42	1.30
HIG3p	Equal variances assumed	3.91	0.05	0.42	547.00	0.67	0.18	0.44	-0.68	1.05
	Equal variances not assumed			0.42	536.43	0.68	0.18	0.44	-0.68	1.05
POW2p	Equal variances assumed	1.70	0.19	1.74	547.00	0.08	0.35	0.20	-0.05	0.75
	Equal variances not assumed			1.73	531.26	0.08	0.35	0.20	-0.05	0.75
POW3p	Equal variances assumed	3.75	0.05	1.08	547.00	0.28	0.19	0.18	-0.16	0.54
	Equal variances not assumed			1.07	527.02	0.28	0.19	0.18	-0.16	0.54
FOR2p	Equal variances assumed	5.96	0.01	1.16	547.00	0.25	0.02	0.01	-0.01	0.04
	Equal variances not assumed			1.16	520.97	0.25	0.02	0.01	-0.01	0.04
FOR3p	Equal variances assumed	12.02	0.00	-0.27	547.00	0.79	0.00	0.01	-0.03	0.02
	Equal variances not assumed			-0.27	509.43	0.79	0.00	0.01	-0.03	0.02
SPE2p	Equal variances assumed	1.81	0.18	2.35	547.00	**0.02***	0.43	0.18	0.07	0.80
	Equal variances not assumed			2.34	533.94	0.02	0.43	0.18	0.07	0.80
SPE3p	Equal variances assumed	22.18	0.00	3.32	547.00	0.00	0.68	0.21	0.28	1.08
	Equal variances not assumed			3.30	488.45	**0.00***	0.68	0.21	0.28	1.09

2p- two points; **3p** – three points

By analyzing table 2 it can be seen that in the column Sig. most of the results are higher than 0.05. That is the reason why the values from the first row (Equal variances assumed) were used for farther analysis. The only variable where the values are lower or the same as 0.05 are POW3p – Power of the jump shot; FOR2p/3p - Force of the jump shot and SPE3p - Speed of the jump shot. For these variables, values from the second row (Equal variances not assumed) were used.

By farther analysis and for determining the difference between groups on initial measurement, values for column Sig. (2-tailed) and from the correct row were used. Difference between groups on initial measurement can be seen at SPE2p - Speed of the jump shot for 2 points with a value of p=0.02 and SPE3p - Speed of the jump shot for 3 points with a value of p=0.00.

By analyzing table 3 it can be seen that in the column Sig. all of the results are lower than 0.05 and that means that for farther analysis the values from a second row (Equal variances not assumed) were used. The only variable witch values form the first row (Equal variances assumed) were used for farther analysis is SPE2p - Speed of the jump shot for 2 points.

By determining the difference between groups on final measurement, values for column Sig. (2-tailed) and from the correct row were used. Difference between groups on final measurement were determent in eight variables (FLT2p/3p – Flight time of the jump shot for 2 and 3 points; HIG2p/3p – Height of the jump shot for 2 and 3 points; POW2p/3p – Power of the jump shot for 2 and 3 points and SPE2p/3p - Speed of the jump shot for 2 and 3 points) with highest level of p=0.00. The only two variables where the differences were not found are FOR2p/3p – Force of the jump shot for 2 and 3 points.

Table 3: Difference between groups on final measurement.

FINAL		F	Sig.	t	df	Sig. (2-tailed)	Mean Dif.	Std. Err. Dif.	Low	Up
FLT2p	Equal variances assumed	65.66	0.00	-7.26	547.00	0.00	-0.05	0.01	-0.06	-0.03
	Equal variances not assumed			-7.20	413.08	**0.00***	-0.05	0.01	-0.06	-0.03
FLT3p	Equal variances assumed	66.34	0.00	-9.40	547.00	0.00	-0.05	0.01	-0.06	-0.04
	Equal variances not assumed			-9.32	421.23	**0.00***	-0.05	0.01	-0.06	-0.04
HIG2p	Equal variances assumed	24.09	0.00	-13.83	547.00	0.00	-5.62	0.41	-6.42	-4.82
	Equal variances not assumed			-13.77	500.96	**0.00***	-5.62	0.41	-6.42	-4.82
HIG3p	Equal variances assumed	19.87	0.00	-17.21	547.00	0.00	-7.49	0.44	-8.35	-6.64
	Equal variances not assumed			-17.13	503.20	**0.00***	-7.49	0.44	-8.35	-6.63
POW2p	Equal variances assumed	41.72	0.00	-8.75	547.00	0.00	-1.48	0.17	-1.81	-1.15
	Equal variances not assumed			-8.70	460.79	**0.00***	-1.48	0.17	-1.81	-1.15
POW3p	Equal variances assumed	34.64	0.00	-11.83	547.00	0.00	-1.96	0.17	-2.29	-1.64
	Equal variances not assumed			-11.75	455.62	**0.00***	-1.96	0.17	-2.29	-1.64
FOR2p	Equal variances assumed	41.65	0.00	-0.68	547.00	0.50	-0.01	0.01	-0.03	0.01
	Equal variances not assumed			-0.68	451.31	0.50	-0.01	0.01	-0.03	0.01
FOR3p	Equal variances assumed	42.52	0.00	-1.45	547.00	0.15	-0.02	0.01	-0.04	0.01
	Equal variances not assumed			-1.44	409.35	0.15	-0.02	0.01	-0.05	0.01
SPE2p	Equal variances assumed	0.93	0.34	-16.04	547.00	**0.00***	-3.20	0.20	-3.60	-2.81
	Equal variances not assumed			-16.03	544.42	0.00	-3.20	0.20	-3.60	-2.81
SPE3p	Equal variances assumed	6.10	0.01	-13.42	547.00	0.00	-2.64	0.20	-3.03	-2.25
	Equal variances not assumed			-13.38	521.09	**0.00***	-2.64	0.20	-3.03	-2.25

2p- two points; **3p** – three points

DISCUSSION

The aim of this study was to determine the difference in explosive strength of lower limbs during the performance of basketball jump shots. Observing the results, it can be concluded that there are differences between groups on initial measurement at two variables (SPE2p/3p) and that there are different at eight variables (FLT2p/3p; HIG2p/3p; POW2p/3p; SPE2p/3p) on the final measurement. Such obtained results indicate that after 10 weeks training program experimental group had changes in the values of the monitoring explosive straight variables.

According to the results from table 1 (Mean column), it can be concluded that after the 10 weeks training program, experimental group values increased. This means, for the explosive strength variables which were monitored, that the training program has had a positive effect. Whit that said, this research, as well as many previous ones (Wilson, Murphy, & Giorgi, 1996; Fatouros et al., 2000; Matavulj, Kukolj, Ugarkovic, Tihanyi, & Jaric, 2001; Shiner, Bishop, & Cosgarea, 2005; Tricoli, Lamas, Carnevale, & Ugrinowitsch, 2005;

Lehance, Croisier, & Bury, 2005; Kotzamanidis, 2006; Markovic, 2007; Markovic, Jukic, Milanovic, & Metikos, 2007; Lehnert, Hůlka, Malý, Fohler, & Zahálka, F. 2013) confirms the positive effect of plyometric exercises on explosive strength. Also, there are some researches about the vertical jump in basketball (Santos & Janeira, 2008; de Villarreal, Kellis, Kraemer, & Izquierdo, 2009; Shallaby, 2010; Santos & Janeira, 2011; Sharma & Multani, 2012) which can confirm the results of this research.

In some researches (Rojas, Cepero, Oña, & Gutierrez, 2000; Okazaki, & Rodacki, 2012; Ramesh, 2014; Tapera, Gundani, Amusa, Makaza, & Goon, 2014; Podmenik, Supej, Čoh, & Erčulj, 2017) it was concluded that height of a vertical jump during jump shot from greater distance is decreasing. This research cannot confirm such a statement because, as you can see in table 1, the mean value of HIG3p is higher than the value of HIG2p. That is the situation on the initial and the final measurement for both groups. However, there are also researches (Tapera, Gundani, Makaza, Amusa, & Goon, 2014; Kant, 2014) in which has been concluded that a successful jump shot should be performed from a higher point. Such a statement is mostly due to the presence of a defender but there are also other reasons. With further distance, target visualization becomes smaller (Walters, Hudson, & Bird, 1990; Satern, 1993; Okazaki & Rodacki, 2012) and in basketball, the only way to decrease that distance is to release the ball in highest point. The shortest path that the ball can cross when it is released is when it is in the same horizontal level with the rim. One way in which this can be done is to jump higher when performing a jump shot. That is the reason why when performing a jump shot vertical jump needs to be as explosive and as high as it can be. In order for players to do such think they need to have a high level of explosive strength.

Aldo, this training program isn't classic plyometric training, it had a positive effect on most explosive strength variables that were monitored such as height of the vertical jump, flight time of the jump shot, power, and speed of jump. If players want to perform a higher vertical jump, they need more muscle straight in lower limbs and it has been shown that plyometric training is the correct method.

CONCLUSION

So far it can be concluded that for performing the jump shot, maximum speed and straight of vertical jump is needed. For doing such a thing the explosive straight of the lower limbs is important. Obviously, according to this and previous researches, plyometric training is the right method for influencing on explosive strength especially when it comes to young players.

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RELATION OF POWER, SPEED AND AGILITY IN BASKETBALL PLAYERS BY POSITION

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SUMMARY

The aim of this study was to determine differences in motor skills among top NBA players. In order to conduct the research, data was collected from the official NBA Draft Combine website, where statistical analysis of information was done in order to determine the differences between players depending on the players' positions. We analyzed the variables that characterize agility and strength, which are integral parts of the battery of tests applied to this draft. Based on "One Way ANOVA", it can be concluded that the arithmetic mean of the applied tests differs significantly in three motor variables at the level of $p \leq 0.01$ in relation to players playing in different positions (Lane Agility Time, Three Quarter Sprint and Max Vertical Leap). In all these variables, groups of players were formed and homogenized with similar average values in relation to body height that definitely determines the values of the performed motor skill tests, as shown by post-hoc analysis. A group of "lower-height" players (Shooting guard, Small forward and Point guard) showed on all three tests that their arithmetic means do not differ statistically, so their test results are very similar, which quite explains the tendency of modern basketball that on the positions 1-3 players can easily rotate.

Cilj ovog istraživanja je bio da se utvrde razlike u motoričkim sposobnostima vrhunskih NBA igrača. Na osnovu podataka sa zvanicnog sajta NBA draft combine uradjena je statistička obrada podataka sa ciljem da se utvrde razlike izmedju igrača u odnosu na poziciju koju igraju. Analizirane su varijable koje karakterišu agilnost i snagu, a koje su sastavni delovi baterije testova koje se primenjuju na ovom draftu. Na osnovu One Way Anove može se zaključiti da aritmetičke sredine primenjenih testova se značajno razlikuju u tri motoricke varijable na nivou $p \leq 0.01$ u odnosu na igrace koji igraju na različitim pozicijama (Lane Agility Time, Three Quarter Sprint and Max Vertical Leap). Kod svih ovih varijabli grupe igrača su se formirale i homogenizovale sa sličnim prosečnim vrednostima u odnosu na telesnu visinu koja definitivno odredjuje vrednosti realizovanih testova motoričkih sposobnosti, sto je pokazano post-hoc analizom. Grupa „nižih" igrača, Shooting guard, Small forward and Point guard, je u sva tri testa pokazala da se njihove aritmetičke sredine statistički značajno ne razlikuju $p \geq 0.01$, tako da su njihovi rezultati na testu veoma slični, što donekle i objašnjava tendenciju savremene košarke da na poziciji 1-3 moze da se lako rotiraju igrači.

Keywords: strength, agility, basketball, player positions

INTRODUCTION

Agility is an important component of many sports but has not been extensively researched (Young & Farrow, 2006). Some studies noted that the improvement in speed, power, and balance should result in an improvement of agility(Sekulic, Spasic, Mirkov, Cavar, & Sattler, 2013). One more study showed that the physiological profile of elite players in the Belgian first division differs by player position. More specifically, guards were characterized by high endurance, speed, and agility, whereas centers and power forwards had higher muscle strength than the other positions. (Boone & Bourgois, 2013). In one research where the strength on bench press 1RM was examined, power forwards and centers were stronger than the rest of the players' positions (Ben Abdelkrim, Chaouachi, Chamari, Chtara, & Castagna, 2010). Some researchers have been investigating basketball footwear requirements depending on playing position (Brauner, Zwinzscher, & Sterzing, 2012). Furthermore, many researches have been looking into physical fitness (Köklü, Alemdaroğlu, Koçak, Erol, & Findikoğlu, 2011) (Scanlan, Tucker, & Dalbo, 2014). In another research where male basketball players were doing agility tests, 20m shuttle run tests, a significant difference was found on the speed and agility tests between playmakers and centers. (Tsitskaris, Theoharopoulos, & Garefis, 2003). The point guard "(PG), also known as "number one (1)", is typically a team's best ball handler and passer. Therefore, they often lead their team in assists and steals. They are often quick and can hit shots either outside the three-point line or "in the paint", largely depending on the player's skill level. Point guards are looked upon as the "floor general" or the "coach on the floor". They should study the game and game film to be able to recognize the weaknesses of the defense, and the strengths of their own offense. They are responsible for directing plays, making the position equivalent to that of quarterback in American football, a playmaker in Association football, center in ice hockey, or setter in volleyball. Good point guards increase team efficiency and generally have a high number of assists. They are often referred to as dribblers or play-makers. In the NBA, point guards are usually the least tall players on the team and are usually 6 feet 5 inches (1.96 m) tall or shorter. The shooting guard "(SG)" is also known as "number two (2)" or the "off guard". Along with a small forward, a shooting guard is often referred to as a wing because of its use in common positioning tactics. As the name suggests, most shooting guards are good shooters from the three-point range. Besides being able to shoot the ball, shooting guards tend to have good ball handling skills and the ability to drive the ball to the basket, often creating their own shots off the dribble. A versatile shooting guard will have good passing skills, allowing them to assume point guard responsibilities known as combo guards. In the NBA, shooting guards usually range between 6 feet 4 inches (1.93 m) and 6 feet 7 inches (2.01 m) in height. The small forward (SF), also known as "number three (3)", is the most versatile of the five main basketball positions. Versatility is key for small forwards because of the nature of their role, which resembles that of a shooting guard more often than that of a power forward. This is why the small forward and the shooting guard positions are often interchangeable and referred to as wings. Small forwards have a variety of assets, such as quickness and strength inside. One common thread among all kinds of small forwards is the ability to "get to the line" and draw fouls by aggressively attempting (post up) plays, lay-ups, or slam dunks. As such, accurate foul shooting is a common skill for small forwards, many of whom record a large portion of their points from the foul line. Besides being able to drive to the basket, they are also good long-range shooters. Some small forwards have good passing skills, allowing them to assume point guard responsibilities known as point forwards. Small forwards should be able to do a little bit of everything on the court, typically playing roles such as swingmen and defensive specialists. In the NBA, small forwards usually range from 6 feet 6 inches (1.98 m) and 6 feet 9 inches (2.06 m) in height. The power forward "(PF)", also known as "number four (4)", often plays a role similar to that of the center, down in the "post" or "low blocks". The power forward is often the team's most versatile scorer, being able to score close to the basket while also being able to shoot mid-range jump shots from 12 to 18 feet away from the basket. Some power forwards, known as "stretch fours", have since extended their shooting range to three-pointers. On defense, they are required to have the strength to guard bigger players close to the basket and to have the athleticism to guard quick players away from the basket. Most power forwards tends to be more versatile than centers since they can be part of plays and are not always in the low block. In the NBA, power forwards usually range from 6 feet 8 inches (2.03 m) and 6 feet 11 inches (2.11 m) in height. The center "(C)", also known as "number five (5)", nicknamed the "pivot", usually plays near the baseline, close to the basket (referred to as the "low post"). They are usually the tallest player on the floor. The center usually scores "down low, in the paint" (near the basket, in the key), but some can be good perimeter shooters. They are typically skilled at gathering rebounds, contesting shots and setting screens on plays. The center position has been traditionally considered [by whom?] one of the most important positions, if not the most important. The range of players used in the position has transitioned from relatively slower but much taller 'back to the basket' players to players who would normally be classified as power forwards but can dominate the position with their defensive skills, or mismatch ability to shoot from the high post. This has been due to the scarcity of players possessing the combination of great skill, ideal height, and durability. This has been matched by the development of more fast-paced and athletic basketball play which calls for less traditional center play and a more up-and-down the court style. In the NBA, centers are usually 6 feet 10 inches (2.08 m) or taller.

METHODS

Subjects

The NBA Draft Combine is a multi-day showcase that takes place every May before the annual June NBA draft. At the combine, college basketball players receive measurements, participate in interviews, undergo shooting drills, take medical tests, go through five-on-five drills and perform various athletic tests in front of National Basketball Association (NBA) coaches, general managers, and scouts. Athletes attend by invitation only. An athlete's performance during the combine can affect perception, draft status, salary, and ultimately the player's career. In this study, the results from the past five years were taken with a total of N = 250 players divided into the following subgroups: Point guard N=58, Shooting guard N=59, Small forward N=43, Power forward N=60 and Center N=30.

Procedure

In this research, we used the variables that are used in the testing of players who were at the draft. Data extracted from the following website: *https://stats.nba.com/draft/combine-strength-agility/,* based on the results from the last 5 years. The athletic tests include an athletes measurements of a standing vertical jump (inches), maximum vertical jump (inches), shuttle run (seconds), three-quarter-court sprint time (seconds) and lane agility time (seconds). The vertical jump - is a test of an athlete's explosive leg power. There are two versions of this test performed, the standard (no step) vertical jump and a running Max Vert. ¾ Court Sprint - Time to sprint over the distance of three-quarters of the court is measured in seconds. Maximum running speed is important in basketball, though the acceleration or time over the first few steps is probably more important. See the details of the 3/4 sprint test procedure. Lane Agility Drill- Agility is very important in basketball and is measured using the lane agility test at the NBA camp. The Lane Agility test measures how fast a player moves laterally around the key.

Statistical analysis

Statistical analysis was carried out on raw data using one-way repeated measures of ANOVA followed by Tukey's post hoc test ($p < 0.01$ was set as the level of statistical significance).

RESULTS

Table 1 One Way ANOVA and descriptive

		MEAN (* $p \leq 0.01$)				
	N	LANE AGILITY TIME*	SHUTTLE RUN	THREE QUARTER S PRINT *	STANDING VERTICAL LEAP	MAX VERTICAL LEAP *
Point guard	58	11.05	3.02	3.24	30.63	37.08
Shooting guard	59	11.08	3.06	3.28	30.04	36.30
Small forward	43	11.32	3.09	3.28	30.51	36.38
Power forward	60	11.55	3.13	3.36	29.47	34.73
Center	30	11.86	3.10	3.41	28.43	32.43

Table 2 Post Hoc Tukey HSD test for Lane Agility Test

POSITION	Subset for alpha = 0.05		
	1	2	3
Point guard	11,0517		
Shooting guard	11,0822		
Small forward	11,3209	11,3209	
Power forward		11,5500	
Center			11,8640
Sig.	,075	,182	1,000

Table 3 Post Hoc Tukey HSD test for Tree Quarter Sprint test

POSITION	Subset for alpha = 0.05	
	1	2
Point guard	3,2393	
Small forward	3,2763	
Shooting guard	3,2825	
Power forward		3,3617
Center		3,4083
Sig.	,321	,246

Table 4 Post Hoc Tukey HSD test for Max Vertical Leap test

POSITION	Subset for alpha = 0.05		
	1	2	3
Center	32,433		
Power forward		34,725	
Shooting guard		36,297	36,297
Small forward		36,384	36,384
Point guard			37,078
Sig.	1,000	,134	,804

DISCUSSION

Table No. 1 shows the results of the descriptive statistics and One Way ANOVA. We notice that in three variables there are statistically significant differences between subgroups, LANE AGILITY TIME, THREE QUARTER SPRINT and MAX VERTICAL LEAP on a level greater than 0.01. These results are mostly very similar to the results of previous researches (Tsitskaris, Theoharopoulos, & Garefis, 2003, Köklü, Alemdaroğlu, Koçak, Erol, & Findikoğlu, 2011). Given that these studies were conducted on a sample of athletes who did not possess the same amount of quality as Draft NBA players, we can conclude that the performance and level of the players do not play a crucial role in the differences in the motor skills of the basketball players compared to the position they play. Variable Lane Agility Time shows that the minimum average time was 11.05 seconds for the point guard subgroup, for which we can say that they were the fastest on this test. The slowest were centers with a time of 11.86 seconds. In the next test, shuttle run, point guards also had the best average time which was 3:02 seconds, while the subgroup "power forwards" had the time of 3.13 seconds, where we see that power forwards are slower than the subgroup "centers" which is very interesting considering that the players at these positions are usually of less height and physically more prepared. Turning technique and coordination is also a large factor in this test. At Three Quarter Sprint variable point guards also had the best average time of 3.24 seconds, small forwards and shooting guards both had the time of 3.28, while centers were the slowest with the time of 3.41 seconds. What is unusual is that on the next test, the point guards had the best results even though speed was not included, At the standing vertical leap the average height of the jump was 30.63 inches; however, the centers had the worst results, with the average jump being 28.43 inches. On the last test, Max Vertical Leap, point guards once more had the best results with an average jump height of 37.08 inches, whereas the centers were the worst with a 32.43 average jump height.

According to post-hoc analysis, shown in the following tables, we can see that subgroups, whose arithmetic means statistically did not differ significantly, have separated from the lowest to the highest players. Table 2 shows that lane agility time test has three subset players, in table no. 3 for THREE QUARTER SPRINT two subsets, for MAX VERTICAL LEAP test in table no. 4 also 3 subsets. The general conclusion is that the highest players of the Subgroup "Center" had the weakest results in the max vertical leap and lane agility time test and they were separated as a special subset with very specific results of motor skills.

CONCLUSION

Based on the conducted research, using data collected from the official website, it can be concluded that the differences in motor skills in treated basketball players compared to the position they play exist and that they are mainly conditioned by anthropometric characteristics. Three Quarter Sprint test shows two groups of basketball players with similar results, table 3. In the other two tests, the Agility and Power test, three groups of athletes were clearly differentiated, where the centers were isolated from other players. The obtained results point to the tendency of the modern basketball that the differences in motor skills are becoming lesser and to look for players who can equally be good at any position.

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DIFFERENCES IN SPEED AND AGILITY OF YOUNG FOOTBALL PLAYERS AFTER THE SAQ EXPERIMENTAL TRAINING PROGRAMME

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SUMMARY

A football match is comprised of repetitive high-intensity short strains, between which there are periods of running (high-, medium- and low-intensity), walking and standing. Speed, agility and quickness (SAQ) are the important determinants of a football player's anaerobic abilities which enable the players to be successful in important moments of the game such as the important ball possession, dribbling opponents and/or scoring. The aim of this research was to establish the differences in speed and agility of 30 young football players of FC 'Vučje'(Vučje), aged 7 to 10, after a six-week-long experimental training programme (2 times a week/12 training sessions/45 minutes in the first part of the training session). Training programme was consisted of SAQ exercises (sprinting, changing directions, foot-worked drills). The results of Student t-test showed the statistically significant difference between two testing situations in the tests estimating starting speed (5m sprint, p = .000) and acceleration (10m sprint, p = .001), whereas there was no statistically significant difference in the third test which estimated maximum speed (40m sprint, p = .118). The results of the tests estimating agility also showed statistically significant difference in Arrowhead agility drill test (p = .000) and Balsom agility test (p = .001), but there was no significant changes in the 505 agility test (p = .116). From the practical point of view, our results show that quickness and agility can be successfully improved in young players (aged 7 to 10) with the application of the organized SAQ training programme. This programme, however, does not seem appropriate when it comes to increasing the maximum speed in 40m sprints at the same time.

Keywords: Speed, agility, experimental programme, young football players

INTRODUCTION

A football match is comprised of repetitive high-intensity short strains, between which there are periods of running (high-, medium- and low-intensity), walking and standing. Even though high-intensity strains are not frequent, they are mandatory for ball possession, scoring and final victory, as the ultimate goal. Over the last decades football has gradually changed its tempo, with the game becoming faster, the players covering a longer distance, and the high-intensity running undergoing certain changes (Casajus, 2001; Helgerud, Engen, Wisløff, and Hoff, 2001; Gil, Gil, Ruiz, Irazusta, and Irazusta, 2007). Some statistical data show that a football player sprints each 90 seconds, with each sprint lasting between 2 and 4 seconds, and changes directions between 1000 to 1400 times during the game (Bahtijarević i Barčot, 2006). The ability of a player to sprint, speed up and slow down with direction changes is known as agility. Agility is defined as a whole body fast movements with speed and direction changes, in response to a stimulus (Sheppard & Young, 2006). Speed, agility and quickness (SAQ) are the important determinants of a football player's anaerobic abilities which enable the players to be successful in important moments of the game (such as the important ball possession, dribbling opponents and/or scoring) (Hammami, Makhlouf, Chtara, Padulo, & Chaouachi, 2015).

Sprinting demands a high level of quickness and strength needed for overcoming body mass inertia. Several studies have examined the relationship between the relative strength and the ability to sprint in young football players and confirmed that stronger football players achieve better results in all maximum speed movements, that is, sprints (Baker & Nance, 1999; Cronin &

Hansen, 2005; Kotzamanidis, Chatzopoulos, Michailidis, Papaiakovou, and Patikas, 2005; Comfort, Bullock & Pearson, 2012). Even though there are well-established advantages of SAQ activities in the training process of young sportsmen and adolescents, so far there have not been researches done with young football players, aged 7 to 10. Training programmes of pre-adolescent football players are comprised of exercises similar to the ones of the SAQ method within the regular technical and tactical training sessions. For example, when training young football players, aged 6 to 12, the activities which are included in the training sessions are deliberately and accidentally chosen (the games adapted to the age and the technical training) and are comprised of multi-directional steps, speeding up, slowing down, turning around, as well as of cognitive stimuli in the form of unpredictable football-related games (Trecroci, Milanović, Rossi, Broggi, Formenti, and Alberti, 2016). Authors Fransen et al (2012) emphasize the fact that the training methods which include the combination of physical and cognitive exercises (SAQ training, for instance) can be more effective with younger children than adults.

Therefore, the aim of this research was to establish the differences in speed and agility of young football players, aged 7 to 10, after a six-week-long experimental training programme. We presumed that the target plan and programme of the training sessions would bring about positive changes in speed and agility of young football players.

METHODS

Subjects

30 football players of the football club 'Vučje' from Vučje, aged 7 to 10, who had been training football actively for a year, participated in the research. All the players and their parents had been familiarised with the aim and the protocol of the research, as well as with the testing method. The parents had given their written consent for their children to participate in the research.

The following measuring instruments were used for evaluating speed and quickness: 5m, 10m and 40m sprints. Measuring instruments were used to assess agility: 505 agility test, Balsom agility test, Arrowhead agility drill test

Procedure

The experimental training programme was conducted in the period of preparations and it lasted for six weeks, 2 times a week (12 training sessions), for 45 minutes in the first part of the training session. After that, the players continued with their regular technical and tactical training. The experimental programme aimed at the development of speed and agility. The training included football movements with and without direction changes, with and without the ball (SAQ training programme).

Table 1. Descriptive characteristics of the 6-week training program for speed and agility

	Speed, Agility and Quickness (SAQ)
Week 1 and 2	– Foot-working exercises using hoops (e.g. split steps, line drills, lateral line hops and multiple hops) – Brief line sprints (over 10, 20, 30m) – Brief sprints with few directional changes (e.g. from 1 to 3) and different angles (30° and 45°)
Week 3 and 4	– Speed-ladder exercises with a combination of basic drills (e.g. one/two in the hole, skipping and hopscotch) – Brief line sprints with a ball (over 10, 20, 30m) – Brief sprints with several directional changes (e.g. from 3 to 5) and different angles (30°, 45° and 90°)
Week 5 and 6	– Speed-ladder exercises with a combination of advanced drills e.g.slaloms, carioca, cha-cha, cherry pickers) – Brief line sprints with/without ball (over 10, 20, 30m) – Agility drills in response to different commands (e.g. right-to-left direction, forward – backward direction)

Table. 2. Description of a training session

Number of series/ repetitions	**Length of a series in minutes**	**Pauses between repetitions (s)**	**Pauses between series (mins)**
3/3	5	30	5

Statistical analysis

Student's T-test was used for determining significant differences between arithmetical means of the applied measuring sets for estimating speed and agility of young football players, before and after the experimental training programme.

RESULTS

The results obtained (Table 3) show the statistically significant difference between two testing situations in the tests estimating starting speed (5m sprint, p = .000) and quickness (10m sprint, p = .001), whereas there was no statistically significant difference in the third test which estimated maximum speed (40m sprint, p = .118). The results of the tests estimating agility also showed statistically significant difference in Arrowhed agility drill test (p = .000) and Balsom agility test (p = .001). There were no statistically significant changes in the third test (505 agility test, p = .116).

Tabele 3. Differences in speed and agility of young football players after a six-week-long training process

Test	N	Mean		T-value	p (< *0.05*)
		Pre ± Std.Dev	Post ± Std.Dev		
5m sprint	30	1.64± 0.16	1.61±0.15	4.34	.000**
10m sprint	30	2.74±0.21	2.71±0.22	4.17	.001**
40m sprint	30	8.19±0.65	8.15±0.65	1.64	.118
505 agility test	30	3.66±0.39	3.57±0.27	1.65	.116
Arrowhed agility drill	30	10.81±0.81	10.77±0.82	5.30	.000**
Balsom agility test	30	17.82±1.39	17.76±1.43	4.10	.001**

DISCUSSION

The aim of this research was to establish the changes of the motor abilities, speed and agility, in young football players, aged 7 to 10, after a programmed training process. The results of the research show that the applied six-week-long training programme had a positive effect on the changes in the starting speed (5m sprint) and quickness (10m sprint), whereas there were no improvements in the maximum speed results (40m sprint). The significant improvement can be ascribed to the SAQ training programme itself (for instance, skips, different jumps and hops, short sprints), all based on a short time contact of a foot with the surface. When working with children aged 10 and 11, applying explosive activities (based on a very short cycle of lengthening and shortening) proved most useful for improving sprint, due to high neuromuscular adaptations (intramuscular coordination) (Michailidis et al., 2013). The results obtained prove the fact that around 90% of all maximum movements during a football match happen at 5m to 15m distance (Bloomfield, Polman, O'Donoghue, and McNaughton, 2007). Along with that, modern football requires reactional ability at 5m to 15m distance (Sporis, Jukic, Ostojic, and Milanovic, 2009). The obtained results rely heavily on the results of the previous researches (Jovanovic, Sporis, Omrcen, and Fiorentini, 2011; Milanovic, Sporis, Trajkovic, James, and Samija, 2013; Trecroci et al., 2016; Azmi and Kusnanik, 2017) which showed that SAQ training programme, lasting from 8 to 12 weeks, could improve the speed, quickness and agility of players. However, after the experimental programme there were no changes in the maximum running speed in 40m sprint, which can be ascribed to the fact that as a sport football is mostly comprised of short-distance movements, which were also a part of the experimental programme. According to Kusnaniku and Rattray (2017), speed and agility can be considered the most dominant traits in football.

Taking into account the fact that the movements observed in the training sessions were short-distance sprints with and without direction changes, hops and jumps (as in the SAQ programme), the obtained results were expected. The examinees' age (7 to 10) is a particularly sensitive period in which almost all motoric abilities can be developed, which is in line with the results of a six-week-long training process. It must be added that the positive changes might also be the result of the technical and tactical training sessions which followed the experimental programme ones.

CONCLUSION

The elements of the SAQ programme training include the exercises and equipment which provoke neural adaptations in both programmed and unpredictable conditions of a football match. Our research shows that the application of this method leads to the improvements in quickness (in 5m and 10m sprints) and agility of the examinees, which is not the case in maximum speed in 40m sprint. The methods and exercises which can be used for improving speed and agility are speed ladder and the repetitions of sprints, with and without direction changes.

From the practical point of view, our results show that quickness and agility can be successfully improved in young players (aged 7 to 10) with the application of the organized SAQ training programme. This programme, however, does not seem appropriate when it comes to increasing the maximum speed in 40m sprints at the same time.

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DIFFERENCES IN SPEED AND BODY COMPOSITION OF BASKETBALL PLAYERS DEPENDING ON THEIR POSITION IN THE TEAM

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SUMMARY

During a game of basketball the players are susceptible to different demands of offense and defense considering the characteristics of the game. To achieve top results in basketball, it is necessary to select the players with particular predispositions and characteristics. Basketball is comprised of a variety of fast, explosive and agile movements. The body composition of the players is different and it largely depends on the position in a team. However, it should be understood that there is no ideal body composition universal to all the sports. The sample of 15 players was divided into three groups depending on the position in a team (guards, forward and centres). The parameters which were the focal points of the research were the differences in speed (Shuttle Test, Sprint Fatigue Test and the Sprint Speed Test in 15m) and the body composition (applying the direct segmental multi-frequency method, using the InBody 770 analyzer). The differences between the players depending on their team position were established by ANOVA analysis for the independent samples and the subsequent Post hoc analysis. The results obtained show that there are no differences in speed. The most notable differences in the body composition between the players and in relation to the position they play are between guards and wings as are between guards and centres.

Keywords: basketball players, body composition, speed, the position in the team, differences.

INTRODUCTION

For the top results to be achieved in basketball, it is important to establish which characteristics, features and abilities should the players possess. It is also necessary to select those players who have special predispositions (such as those who run fast, jump high and do quick directions changes) which are manifested during the period of growth and development (Popović, Smajić, Molnar and Mašanović, 2009). Basketball has intensively developed over the time and nowadays it is one of the most dynamic sports which requires perfect forms and work methods that can produce results in the near future. The structure of basketball is comprised of fast, explosive and agile movements (short sprints, quick stops and speeding up, direction changes, various types of jumping, passing and throwing the ball) (Nikolić, Kocić, Berić & Jezdimirović, 2015; Nikolić, Berić, Kocić & Daskalovski, 2016). The fact is that ideal body composition and physiological requirements are not sufficient for achieving top results in basketball (Ransone, 2016). Players' body composition differs depending on the position in the team (Jesús Ramos-Campo et al., 2014). The body composition is the estimate of the subcuttaneous fatty tissue as well as muscular and bone mass in the body (Mišigoj- Duraković et al, 1999). The body composition is defined as a relative proportion between the fats and the body mass (ACSM, 2005). Basketball, as a physically challenging game, depends on numerous motor abilities, including the speed of running. In order to increase the result values of short sprints, plyometric training is used, being efficient and easily applicable (Asadi et al., 2016). It has been estimated that top basketball players cover the distance between 3500 and 5000m during a game (Janeira & Maia, 1998). It has also been shown that a player does around 1000 two-minute-long activities per game (Abdelkrim, El Fazaa, & El Ati, 2007). Speed is the ability important for the players regardless of the position in the team, with the aim of accelerating the transition between offense and defense (Nikolić, 2016). A professional basketball player does one or two-second-long sprints 105±52 times per game (Castagna et al., 2009). The research conducted in Australian National Basketball League games by McInnes et al. (1995) shows that the longest sprint was 5.5 seconds, that 5% of all the sprints were longer than 4 seconds, whereas the largest number of sprints (51%) was between 1.5 and 2 seconds. On average, the sprints lasted for 1.7 seconds. Basketball is the game of tall people who should play in the positions under the basket (positions 4 and 5). These players should undergo special speed developing training (Jakovljević, Karalejić, Pajić & Mandić, 2011). The analysis of the game characteristics, the number of players who take part, the size of the court has shown that for achieving top results the players need to move with unabated dynamics and movement control, with the aim of getting into the most favourable position for the successful ending of the action (Kuliš, 2010). That is the reason why speed development is crucial in modern basketball so it is essential to organize a special training process, starting from the youngest players to the senior categories (Trunić, 2007). Speed represents man's ability to complete a frequency of movements over a certain period of time, or just one movement in the shortest period of time (Milenković & Simić, 2009). In basketball, speed is important for all players' positions. Backs/ Guards should be able to demonstrate speed and explosive abilities in all the aspects of the game. In offense, because they organize it (fast and secure passing the ball from the defensive to the offensive half of the court) and in defense, because they need to guard the opponent players (Kocić, 2007). Their greatest responsibility is to organize and control the game. Wings and center extort personal fouls and score points. The players in these positions should be able to score successfully not only from the inner but also from the outer positions. Defensive centers have the task to obtain rebounds by timely blocking while jumping. In offense, by timely demarking and positioning, they have the task to come closer to the basket , jump in defense and block (Kocić, 2007). Players' speed differs depending on their positions in the team (Tsitskaris, Theoharopoulos & Garefis, 2003; Delextrat & Cohen, 2009) in that the playmakers and guards have better results when compared to the players in the center position. It has also been proven that the players of the higher-ranking competitions show better results when it comes to speed depending on the position they have in the team (Kocić, Berić, Radovanović & Simović, 2012). The aim of this research was to establish the differences in the body composition and speed in top basketball players depending on their positions in the team.

METHODS

Subjects

15 basketball players of the basketball club "Konstantin" from Niš participated in this research. The examinees were divided into three groups as follows: guards (playmakers and shooting guards, 1 and 2), forwards and short post (3 and 4) and centers (5). The players of the basketball club "Konstantin" compete in the Serbian Second National League in the 2018/ 19 season.

Procedure

The body composition was measured by InBody 770 analyzer which uses the direct segmental multi-frequency method (Direct Segmental Multi-frequency – DSM method) of the bioelectric impedance analysis. The method uses a different frequency range from 1kHz to 1 MHz and the reactive measuring of the quantity or mass of all four major body components, water, fat, proteins and minerals, with the high degree of accuracy. Before the measuring all the examinees were given the recommendation to which they adhered (Radovanović & Đurašković, 2018). The following set of measuring instruments was used for estimating speed: 10x5m Shuttle Test (10X5m); Sprint Fatigue Test (SFT); 15m Sprint Speed (S15m). All the measuring instruments were taken from Topend Sports: http://www.topendsports.com/testing/tests/index.htm (in Nikolić, 2016).

Statistical analysis

The differences between the players depending on their team position were established by ANOVA analysis for the independent samples (the statistical level of significance $p<0,05$) and the subsequent Post hoc analysis.

RESULTS

Table 1 Univariate analysis of the speed variance between the players in the same positions

Tests	Mean (guard)	Mean (forward)	Mean (center)	F	P-level
15m	2.51	2.55	2.59	0.63	.548
10x5m	15.66	16.00	15.54	0.81	.466
Sprint fatigue test	0.98	1.01	0.99	0.62	.555

Univariate analysis of the speed variance (Table 1) shows that there are no statistically significant differences in the tests of the players' speed depending on the position they have in the team, based on the F-relations and their significance (P-level). Further post hoc analysis is not necessary since the significance of the differences between arithmetical means between the groups is at a low level.

Table 2 Univariate analysis of the body composition variance between the players in the different positions

Tests	Mean (guard)	Mean (forward)	Mean (center)	F	P-level
Weight	78.48	90.34	98.74	6.69	**.011**
SMM	39.48	45.42	48.20	7.36	**.008**
BFM	9.24	11.22	14.06	1.67	.229
PBF	11.62	12.34	13.96	0.57	.581
RA	0.38	0.37	0.38	1.17	.342
LA	0.37	0.37	0.38	1.64	.234
Trunk	0.37	0.37	0.38	4.30	**.039**
RL	0.37	0.37	0.38	4.73	**.031**
LL	0.37	0.37	0.38	4.90	**.028**

Univariate analysis of the body composition variance (Table 2) shows that there are statistically significant differences in the following measurements: Weight .011, SMM .008, Trunk .039, RL .031 and LL .028, based on the F-relations and their significance (P-level).

Table 3 The final definition of the notable differences is obtained through the post hoc test (Fisher LSD test)

Weight	{1} 78.48	{2} 90.34	{3} 98.74
1 - guard		.055	**.003**
2 - forward	.055		.157
3 - center	**.003**	.157	
SMM	{1} 39.48	{2} 45.42	{3} 48.20
1 - guard		**.025**	**.003**
2 - forward	**.025**		.254
3 - center	**.003**	.254	
Trunk	{1} 0.37	{2} 0.37	{3} 0.38
1 - guard		.670	**.041**
2 - forward	.670		**.018**
3 - center	**.041**	**.018**	
RL	{1} 0.37	{2} 0.37	{3} 0.38
1 - guard		.313	.072
2 - forward	.313		**.011**
3 - center	.072	**.011**	
LL	{1} 0.37	{2} 0.37	{3} 0.38
1 - guard		.730	**.027**
2 - forward	.730		**.014**
3 - center	**.027**	**.014**	

Statistical difference is notable between guards and centres (.003), guards and centres (.003) and guards and forward (0.25), between guards and centers (0.41) and forward and centers (0.18) and between forward and centers (.011).

DISCUSSION

Previous research has proven that there are differences in basketball players' speed depending on the position that they have in the team (Kocić, 2005; Popović, Smajić, Molnar & Mašanović, 2009; Nikolić, Kocić, Berić & Jezdimirović, 2015; Nikolić, Berić, Kocić & Daskalovski, 2016). However, the results of this research show that such differences do not exist. The results are related to the moment in which the testing took place and the period, since speed as a segment of the comprehensive preparation in a specific way has not been estimated yet. Everyone's motor efficiency is directly linked to the level and the relationship between anthropological characteristics, the fact that the differences do not exist can only be ascribed to the following factor groups: the systematic influence of the training sessions which are the same for the members of one team, the less systematic influence of the games played which changes from one game to another and is different for the members of one team and the non-systematic influence of all the other factors (Kocić, 2005). The very non-existence of the differences should probably be linked to the selection of the players, because minimum results in this test were achieved by the players in the positions of centers. The structure of movements is, to a large extent, also related to cognitive abilities. It is a known fact that the coordination results (which are closely related to speed) are influenced by extrovert and introvert models of behaviour (Kocić, 2005). The results of this research show that players' body composition is different, depending on the position the players have in the team, the fact which has been supported in some previous research (Jesús Ramos-Campo, et al., 2014). The results have shown that there are differences in the players' body composition depending on the position they have in the team and that the largest ones are between guards and forwards and guards and centers. It is also known that the sports weight is defined as the ideal mass for the successful participation in certain sports or sport disciplines, that is, the ideal mass for a particular sport (Radovanović & Ponorac, 2015). However, the pressure to achieve and maintain certain body mass surpasses the training sessions or competitions and penetrates all the aspects of the life of a sports person (Radovanović & Ponorac, 2015). The body composition influences the speed and agility in a majority of sports people, in that the lower the body mass values, the higher the values of speed and agility when doing certain sport-specific tasks (Jeukendrup & Gleeson, 2010). The changes in the body composition of top players can influence the positioning in the team (Santos et al., 2014). Top players' body composition influences the position in the team the players occupy considering the characteristics of the game of basketball, which is what this study confirmed (Alejandro, Santiago, Gerardo, Juan Carlos & Vicente, 2015).

CONCLUSION

The results obtained show that there are no differences in speed but that the differences are obvious when it comes to the body composition, that is, the players' position in the team. These results can serve as an auxiliary method for establishing the extent to which the players have been trained. As well as that, the obtained results can serve as a guideline on planning and programming specific training sessions for the players who are in the position of a guard, a forward and the center as well as on the players' selection for a certain team position.

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GENERIC MODEL OF OPTIMAL BODY COMPOSITION PREDICTION OF ELITE MALE VOLLEYBALL

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SUMMARY

It is known that body composition is a general indicator of the condition of the human organism and it is influenced by the effects of numerous factors, such as diet, health condition, level of physical activity, stress and other. One of the most important factors for the body composition is the individual's level of physical activity. It is known that, under the direct influence of a certain sport, the structure of the athlete's body adapts to the requirements of that sport. Purpose of the research is to find a generic model of optimal body composition for top volleyball players. Subjects sample consists of 22 elite volleyball players aged 26.86 ± 3.12 years (Min-Max = 20-33 years), National team members. Measurement of body composition was carried out by a standard procedure using the method of electrical multichannel bioimpedance (BIA). The total number of variables is 17, as follows: primary variables (7), variables partialized in relation to longitudinality (5), variables partialized in relation to volume (4) and specific body structure variable (1). Number of variables in the morphological structure of the body is reduced by factor analysis. Three variables (factors) were isolated in final factor iteration: the percentage of body fat (PBF), the total weight of the free fat component (FFM), and the protein mass index (PMI). For the purposes of evaluation and prediction of morphological status of elite volleyball players, a multidimensional score (Morph_Point_SCORE) was defined using Mathematical modeling and Multivariate Regression Analysis. The research was conducted on elite volleyball players and provides a more detailed picture of the morphological characteristics of top athletes. Thus, research results could serve as reference values for future research that would investigate the area of elite male volleyball body composition. The practical significance of the research is that it provides, to both coaches and other practitioners, additional information about which body structure corresponds to a defined model of body composition.

Keywords: Bioimpedance, Volleyball, Body composition

INTRODUCTION

Volleyball is a sport that sets high and complex technical, tactical and physical requirements for the players which are closely linked to the development of certain motor abilities and specific motor skills (Fathi et al., 2018). Apart from the variables belonging to the motor area, it is considered that certain morphological characteristics of the player also have significant influence on the achievement of volleyball success (Rico-Sanz, 1998).

It is known that body composition is a general indicator of the condition of the human organism and it is influenced by the effects of numerous factors, such as diet, health condition, level of physical activity, stress and other. It is presents by parameters that indicate the value of bone, fat and muscle tissue, the amount of water and minerals in the body, as well as other components that make up the body mass of a human (Djordjevic-Nikic & Dopsaj, 2013).

The morphological structure of the organism is a variable measure and in addition to the aforementioned, way of life, gender differences (Wells, 2007) and aging influence should also be considered. One of the most important factors for the body composition is the individual's level of physical activity. It is known that, under the direct influence of a certain sport, the structure of the athlete's body adapts to the requirements of that sport (Carbuhn et al., 2010). For this reason, measuring and monitoring of body composition is an important part of the sports diagnostics that points to the general health conditions of an athlete and is an important component for profiling the elite athlete, in this case volleyball player.

Top athletes usually have an extremely intense and dense schedule with great number of trainings and games. In addition to club appearances, certain athletes play for their National Teams which means additional hours spent on the field and often insufficient time to rest. The popularization of volleyball at the global level has caused the competitions to be organized around the world and this presents an additional effort for elite volleyball players. It is considered that a large number of long journeys annually and an often changes of the time zones can lead to the biological rhythm disorder, and therefore the parameters of the athletes' body composition (Bankovic et al., 2018). Also, injuries that accompany volleyball players during the season, as well as frequent eating disorders, as the starting components of sports preparation, contribute to changes in the morphological structure (Stiegler & Cunliffe, 2006). Therefore, adequate measurements and continuous body composition monitoring of top volleyball players is important both for health reasons and in terms of bringing their bodies into an adequate state so they can respond to the demands of frequent and highly intensive training and matches (Garthe, Raastad, Refsnes, Koivisto, & Sundgot-Borgen, 2011).

Regarding the aforementioned, the aim of the research is to find a generic model of optimal body composition for top volleyball players.

METHODS

Subjects

Subjects sample consists of 22 elite volleyball players aged 26.86 ± 3.12 years (Min-Max = 20-33 years), National team members. Volleyball players play at the following positions: Setter (4), Outside hitter (6), Middle Blocker (5), Opposite (4), Libero (3). All respondents were informed about the measurement protocol and gave their own consent to participate in this research. The research was carried out according to the Declaration of Helsinki.

Procedure

Study protocol involved body height (TV) and body composition measurements. All measurements were carried out in the early hours starting at 08:00 in the Methodical Research Laboratory (MIL) of the Faculty of Sport and Physical Education, University of Belgrade. Measurement of body height was performed using anthropometer (GPM, Swissmade) with a measurement accuracy of 0.001 m. Measurement of body composition was carried out by a standard procedure (Dopsaj, Valdevit, Ilić, Pavlović & Petronijević, 2017) using the method of electrical multichannel bioimpedance (BIA) carried out by a body composition analysis device - InBody 720 (Biospace Co., Ltd, Seoul, Korea). On the day before the measurement, players carried out an evening practice of lesser intensity for 60 minutes. Measurements were conducted before breakfast and morning training.

Variables used to define the body composition of a volleyball player can be divided into four groups. In addition to the group of primary variables of volleyball players body composition, indexed variables were determined: the group of variables related to the body longitudinal dimensionality, the group of variables that referred to the percentage share of certain body components and groups of combined indexed variables.

The total number of variables is 17, as follows: primary variables (7), variables partialized in relation to longitudinality (5), variables partialized in relation to volume (4) and specific body structure variable (1) (Dopsaj, M., Valdevit, Z., Ilić, D., Pavlović, Lj., & Petronijević, 2017; Santos et al., 2014).

Main body composition variables:

- BH - body height, expressed in cm,
- BFM - total mass of the fat component, expressed in kg,
- FFM - total mass of the free fat component, expressed in kg,
- PM - total protein mass, expressed in kg,
- SMM - total muscle mass, expressed in kg,
- TBW - the total amount of water in the body, expressed in L,
- VFA - visceral fat area, expressed in cm^2

Variables partialized in relation to longitudinality:

- BMI - body mass index, expressed in kg/m^2,
- FMI - fat component index, expressed in kg/m^2,
- FFMI – free fat component index, expressed in kg/m^2,
- PMI - protein mass index, expressed in kg/m^2,
- SMMI - muscle mass index, expressed in kg/m^2.

Variables partitioned in relation to volume:

- PBF - body fat percentage, expressed in %
- PP – body proteins percentage, expressed in %

- PSMM – body muscles percentage, expressed in %
- PTBW – body water percentage, expressed in %.

Specific body structure variable:

- PFI – protein and body fat ratio, expressed in kg.

Statistical analysis

In the first step of processing, all data was subjected to descriptive statistical analysis in order to define relevant measures of central tendency, data dispersion and data range, that is a mean value (MEAN), standard deviation (SD), coefficient of variation (cV%), minimum (Min) and maximum (Max). Normality of results distribution was determined by application of Shapiro-Wilk goodness of fit test. Principal component analysis of the first and second order using Kaiser's criterion with direct Oblimin rotation was used to reduce morphological variables into factors, and to define standardized factor scores. In the next step of the analysis mathematical modeling, i.e. multidimensional scaling was used in order to transform factor scores into mathematical analogy where the factor score of each subject was transformed in proportional score on a linear scale (Dopsaj, Ćopić, Nešić & Sikimić, 2010). In process of defining a relevant statistical model, Multivariate Regression Analysis (MRA) was used. In this analysis, the value of point score represented the criterion variable, and the results of a system of morphological variables with the highest factor loading represented a system of predictor variables. The optimal form of prediction model was defined using variables with the highest loading in each of the extracted factors. The level of statistical significance was defined based on criterion $p \leq 0.05$. All analyses were conducted using statistical software Microsoft Office Excel 2007 and IBM SPSS v23.0.

For the purposes of evaluation and prediction of morphological status of elite volleyball players, a multidimensional score (Morph_Point_SCORE) was defined using Mathematical modeling and Multivariate Regression Analysis. This score represents the position of the participant on a hypothetical scale with a minimum of 0 and a maximum of 100 points, thus giving relevant data in relation morphological characteristics and, indirectly, performance potential of a given athlete.

RESULTS

Table 1. Basic descriptive indicators of the tested variables with the results of statistical testing of the normality of the distribution

Descriptive Statistics							
	Mean	Std. Deviation	cV%	Min.	Max.	S-W	P
BH (cm)	198.78	5.10	2.57	188.40	206.10	0.956	0.418
BMI (kg/m²)	23.72	1.33	5.59	21.35	25.61	0.935	0.158
TBW (L)	62.65	4.24	6.77	56.20	72.30	0.965	0.602
BFM (kg)	8.21	3.26	39.69	2.40	16.60	0.951	0.332
PM (kg)	17.05	1.16	6.79	15.30	19.70	0.964	0.571
SMM (kg)	49.41	3.50	7.09	44.00	57.40	0.965	0.603
FFM (kg)	85.53	5.82	6.80	76.90	98.80	0.964	0.567
PBF (%)	8.73	3.37	38.63	2.94	17.17	0.953	0.366
PP (%)	18.19	0.73	4.01	16.34	19.51	0.953	0.357
PSMM (%)	52.73	2.20	4.16	47.26	56.44	0.953	0.357
PTBW (%)	66.86	2.43	3.63	60.81	71.04	0.956	0.405
VFA (cm²)	37.56	21.61	57.52	11.00	84.00	0.932	0.135
FMI (kg/m²)	2.08	0.86	41.01	0.63	4.35	0.953	0.358
PMI (kg/m²)	4.31	0.25	5.90	3.93	4.78	0.932	0.136
SMMI (kg/m²)	12.50	0.76	6.07	11.35	13.92	0.932	0.138
PFI (kg)	2.48	1.24	49.98	0.95	6.63	0.836	0.002
FFMI (kg/m²)	21.64	1.22	5.66	19.73	23.95	0.936	0.167

Prior to performing Principal Component Analysis, the suitability of data for factor analysis was assessed. Inspection of the correlation matrix revealed the presence of a number of coefficients above the value of 0.3. The Kaiser-Meyer-Olkin value was determined to be 0.658, exceeding the recommended value. The Bartlett's Test of Sphericity was statistically significant (p=0.000). Both aforementioned facts support the factorability of the correlation matrix. Principal Components Analysis revealed the presence of only 3 components with eigenvalues exceeding the value of 1. The extracted components explained 55.48, 27.94 and 13.30% of the variance, respectively. In order to define the most optimal model of morphological characteristics of the sample, the number of variables was further reduced within the extracted factors.

The results of defined MRA model have shown that the extracted factors explained 100% of the measured variance ($_{Adj}R^2$=1.000) in relation to examined morphological characteristics, which means that predictive potential relative to characteristics of the sample is absolute. ANOVA regression has shown an extremely high level of statistical significance of score prediction (F=208463373.138, p=0.000) for Morph_Point_SCORE variable. The value of the standard error of prediction was at the level of 0.00305 points and can be considered minor.

Table 3. Structure matrix of extracted factors

	Structure Matrix		
	Component		
	1	2	3
BH (cm)	**-1.007**	0.043	0.030
BMI (kg/m²)	**0.982**	0.039	0.017
TBW (kg)	**-0.980**	0.119	-0.085
BFM (kg)	**0.972**	-0.004	0.085
PM (kg)	**-0.972**	0.005	-0.087
SMM (kg)	**0.964**	0.060	0.072
FFM (kg)	**0.926**	-0.044	-0.103
PBF (%)	**-0.820**	-0.156	0.066
PP (%)	-0.504	**0.919**	0.091
PSMM (%)	0.191	**0.915**	0.108
PTBW (%)	0.137	**0.913**	0.158
VFA (cm²)	0.198	**0.898**	0.145
FMI (kg/m²)	-0.050	-0.632	**0.964**
PMI (kg/m²)	0.059	0.290	**0.865**
SMMI (kg/m²)	0.067	0.287	**0.864**
PFI (kg)	0.119	0.315	**0.829**
FFMI (kg/m²)	0.124	0.315	**0.827**

Table 3. The defined mathematical model for prediction of optimal body composition in elite volleyball players

Morph_Point_SCORE=-165.9305207-1.7572490*PBF+1.2686596*FFM+28.4596006*PMI

DISCUSSION

Descriptive statistics results indicate that the Serbian national team is on average 198.78 ± 5.10 cm high, which is more than the sample of professional Indian (173.10 ± 5.10 cm) (Bandyopadhyay, 2007), Greece National level (193.55 ± 6.48 cm) (Giannopoulos, Vagenas, Noutsos, Barzouka, & Bergeles, 2017)and Italian (191.9 ± 9.7 cm) (Campa & Toselli, 2018) volleyball players. When it comes to BMI values, Serbian national team members with 23.72 ± 1.33 kg/m² have higher values compared to Indian (19.59 ± 1.57 kg/m²), while slightly higher values of BMI were observed among players in Greece first and second divisions (Giannopoulos et al., 2017) and Turkish university volleyball players (Pelin, Kürkçüoğlu, Ozener, & Yazici, 2009), and almost equal to volleyball players from Italian first and second division. Greeks and Italians have a higher fat mass component, BFM = 11.1 ± 2.9 kg (Campa & Toselli, 2018) and 14.18 ± 9.97 kg (Giannopoulos et al., 2017) in comparison with Serbs 8.21 ± 3.26 kg, and in relation to that, a higher body fat percentage PBF = 12.7 ± 3.0% (Campa & Toselli, 2018) and 15.32 ± 3.16% (Giannopoulos et al., 2017) compared to Serbian volleyball players (8.73 ± 3.37%). The total mass of the fat free component FFM (kg) is significantly higher for Serbian nationals of 85.53 ± 5.82 kg than for Italian (75.7 ± 8.9 kg) (Campa & Toselli, 2018) and Greek volleyball players (77.33 ± 7.23 kg) (Giannopoulos, Vagenas, Noutsos, Barzouka, & Bergeles, 2017). As for total body water, our athletes have higher values TBW = 62.65 ± 4.24 L than Italian volleyballs 53.5 ± 5.6 L (Campa & Toselli, 2018).

Comparing the variables of the athlete's body composition with subjects from other professions which require physical preparation, certain differences can be noticed. In comparison with volleyball players, Abu Dhabi police officers have a lower muscle mass (SMM = 34.47 ± 4.78 kg) and accordingly less protein mass percentage (PPM = 14.87 ± 1.51%) and muscle mass percentage (PSMM = 43.31 ± 4.49%). On the basis of the above mentioned, it is logical that volleyball players have a higher muscle mass per square meter of body height than Abu Dhabi police (SMMI = 11.19 ± 1.25 kg/m^2) (Kukić & Dopsaj, 2016)

Athlete's morphological structure is formed in accordance with the requirements of various sports. Thus, in comparison to volleyballs, top martial arts sports competitors have more fat (FMI = 2.74 ± 1.22 kg/m^2) and protein (PMI = 4.51 ± 0.46 kg/m^2) per square height. When it comes to specific body structure indications such as the protein to fat ratio (PFI), martial arts sports have higher values (PFI = 2.02 ± 1.13 kg) (Dopsaj et al., 2017) compared to volleyball players. Compared to the Serbian national handball team, Serbian volleyball players have a lower percentage of body fat (PBF = 12.60 ± 3.97% - 8.73 ± 3.37%), almost similar values of the fat free body mass component (FFM = 85.23 ± 6.64kg - 85.53 ± 5.82kg) and a slightly more water percentage in the body (PTBW = 64.06 ± 2.99% - 66.86 ± 2.43%) (Dopsaj, Valdevit, Ilić, Pavlović & Petronijević, 2017) .

By analyzing the results of descriptive statistics it can be argued that the measured variables of the Serbian national team volleyball player's body composition are at an exceptional level, especially if we take into account more muscle mass and lower body fat values. Large number of variables in the morphological structure of the body is reduced to factors through factor analysis. In the first round, three factors are distinguished: factor 1 (BH, BMI, TBW, BFM, PM, SMM, FFM, PBF), factor 2 (PP, PSMM, PTBW, VFA) and factor 3 (FMI, PMI, SMMI, PFI, FFMI). Three other variables (factors): the percentage of body fat (PBF), the total weight of the fat free component (FFM), and the protein mass index (PMI) were isolated from the further steps of factor analysis.

The first isolated factor refers to the ballast tissue. It is known that excess body fat represents an additional burden that can affect certain motor skills manifestation. Athlete's body fat percentage varies from sport to sport (Barr, McCargar, & Crawford, 1994), however in sports that feature a large number of jumps, landings, rapid changes in the movement direction, among which is volleyball, the percentage of body fat should be reduced to low values. Another important component of the volleyball player's optimum body composition model is the fat free mass component.

It is considered to be of importance for athletes that, with a low body fat percentage, other components of the morphological structure, such as minerals, body water, proteins and others, are also in a balanced relationship (Stiegler & Cunliffe, 2006). The third isolated and most influential factor is the protein mass index. Protein is a significant building element that is a part of the muscle composition, so the protein mass in the body is associated with muscle mass (Phillips, 2004). However, in addition to the absolute protein-mass index in the body, the relative weight of the protein mass, i.e. the protein mass in comparison to the longitudinality of the body, is a very significant indicator. In sports branches that require powerful, explosive movements, the protein mass per square meter of body height is an indicator of a pure contractile substance that represents a biological basis for the quality manifestation of contractile muscle properties. Thus, in volleyball, it is important that the protein mass per square inch of body height is at an optimal level in order for the volleyball player to respond to the demands such as a large number of maximum and sub-maximal jumps, strong strikes during service and attack.

Finally, with the multiple regression analysis the influence of the selected variables on the score (Morph_Point_SCORE) was obtained, and the equation of the optimal body composition of the volleyball player based on the body fat percentage-PBF, free fat mass component-FFM and the protein mass index-PMI. Thus a useful means for the level of physical status determination of top-level volleyball players has been obtained, as well as a comprehensive reference model for comparing the body dimensions of volleyball players at different levels of training, to determine possible differences in relation to a representative sample of elite athletes.

CONCLUSION

The aim of the research is to find a generic model of optimal body composition for top volleyball players. By factor analysis, a large number of morphological variables are reduced to three factors. Highlighted variables were, body fat percentage (PBF) as a relative indicator of ballast excessive fat tissue in an athlete's body, the free fat mass component (FFM) as an absolute indication of other components constituting the body structure and the protein mass index (PMI) as a relative amount of pure contractile tissue per square height. For the purpose of quantifying the morphological status of top volleyball players, a score (Morph_Point_SCORE), which represents the individual's position relative to the scale from 0 to 100, is calculated. On the basis of multiple regression analysis, the model of the elite volleyball player's body composition was obtained:

Morph_Point_SCORE = -165.9305207-1.7572490*PBF+1.2686596*FFM+28.4596006*PMI

The significance of this research is reflected by its sample of subjects. The research was conducted on elite volleyball players and provides a more detailed picture of the morphological characteristics of top athletes. Thus, research results could serve as reference values for future research that would deal with a similar topic.

The practical significance of the research is that it provides, to coaches and other practitioners, additional information about which body structure corresponds to a representative model. Practical significance is also reflected in the participation of the factor of the model obtained on the body composition, that is, which parameter of the body composition should be increased and which reduced or maintained at an optimal level. Future research should define models of optimum body structure for female population and different age categories, as well as for individual volleyball positions.

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DIFFERENCES IN THE LEVEL OF BASIC AND SPECIFIC MOTOR ABILITIES OF BASKETBALL PLAYERS WITH RESPECT TO THEIR POSITION IN THE TEAM

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SUMMARY

The research was conducted with the aim to establish current level of motor abilities of basketball players currently selected in the cadet basketball team of Bosnia and Herzegovina, as well as differences between them with respect to their position in the team. Basketball players from the best clubs in the Republic of Srpska and Federation of Bosnia and Herzegovina took part in this research. Total number of participants is 16 selected players divided into two groups according to their position (inside or outside). Upon statistical data processing research results suggested that there are statistically significant differences in all the tested motor abilities between the two aforementioned groups of subjects.

Key words: motor abilities, basketball players, outside position, inside position, differences

INTRODUCTION

Cadets are boys aged 14 to 16 which is a period of mid-youth, puberty and start of adolescence. At this particular point growth and development slow down as growing in width increases and body proportions begin to become balanced. Ossification is almost complete, muscle tonus increases and functional abilities of muscles start to resemble one of an adult. Cardiac muscle grows stronger and the disproportion between mass and volume of heart decreases. Balance in development of individual organs and systems establishes itself. Prescribed model of basketball play in its basic elements should already be adopted at this particular point. In terms of physical preparation activities are directed towards development of motor and functional abilities, particularly ones with sensitive phase in progress (speed, coordination and balance). Aerobic and anaerobic performance of endurance is being developed respectively and performance of endurance in speed and strength is starting to be developed. In terms of topic of this paper which deals with analysis of plyometrics, agility, anaerobic endurance and speed of young basketball players, we consulted similar relevant literature. In the paper (Jurić et al. 2003) it is suggested that one player jumps 30 to 65 times on average in course of single game. In diploma paper (Janjušević, 2017) sample of 30 male participants was divided in two sub-samples: cadets and juniors, and it was concluded that the groups are different at statistically significant level relative to their basic motor abilities and specific motor abilities. Juniors had higher values compared to cadets at the level of basic motor abilities. Authors (Berić, & Kocić, 2010) state that jumps require more physical predispositions. They require significant effort, determination and correct presentation of technique. Probably the best proof of significance of jumps is high correlation between successful jumps and victory. Jump in offence shows determination and efforts of team to win more than any other element of offence technique. In addition to that, jump in offence represents prevention of counter-strike. In their paper, (Matavulj, Kukolj, Ugarkovic, Tihanyi, & Jarić, 2001) established that plyometric training leads to improvement in height of vertical jump in junior basketball players. Similar results were also obtained by (Kukrić, Petrović, Dobraš, & Guzina, 2010) because they had established that plyometric training in course of 10 weeks (with frequency of 2 times a week) where the number of exercises and number of jumps per training increases by each week and where the break between the series is 3 minutes and between exercises 5 minutes leads to increase in vertical jump of junior basketball players. Author (Radaković, 2017), in his diploma paper established in on the sample of 30 male basketball players and 22 female basketball players from several Croatian basketball clubs competing at highest national level that there is statistically significant difference in the area of agility between the groups of cadets and juniors – male basketball players and cadets and juniors – female basketball players. Authors (Kocić, Berić, Radovanović, & Simović, 2012) apply on the sample of 97 participants divided into two sub-samples: the first of 48 competing in the League of Serbia and 49 competing in the First National Basketball League three sets of variables for assessment of motor, situational-motor and functional abilities and they state that there are statistically significant differences in motor and functional abilities (aerobic endurance) in basketball players at higher competition rank. Authors (Erčulj,Dezman, & Vučković, 2004) mentioned the findings of Gorjana where it had been stated that jumps by both feet are dominant in basketball and used in 86% of situations. Basketball, being a game, in addition to physical contact involves physical efforts such as running, jumping and rapid stopping which all demand great physical strength (Vamvakoudis et al. 2007). In large number of papers research conducted suggested that the players competing at national level of competition achieved higher results in numbers presenting explosive strength, agility, repetitive strength, psycho-motor speed and flexibility (Aglioti, Cesari, Romani, & Urgesi, 2008; Trunić, 2006; Ostojić, Mazić, & Dikić, 2005; Sallet, Perrier, Ferret, Vitelli, & Baverel 2005; Ćeremidžić, 2005; Jovanović-Golubović, & Kocić 2002; Dopsay, & Matavulj 1993), as well as greater tactical and technical knowledge (Trunić, 2006; Jakovljević, 2007; Apostolidis, Nassis, Bolatoglou, & Geladas 2004; Erčulj, Dežman, & Vučković, 2003) in comparison to players competing at lower rank. Subject of this paper are motor abilities of basketball players in the cadet team of Bosnia and Herzegovina. Aim of the research was to establish differences in motor abilities between the players at inside and outside positions.

METHODS

Subjects

Sample consisted of 16 basketball players of the cadet team of Bosnia and Herzegovina. All the participants had been in the training process for at least five years. They did the tests, which are constituent part of every serious working agenda, on voluntary basis.

Procedure

Choice of variables was performed in line with the subject and aim of research. For the purpose of assessment of motor abilities of the above stated selected basketball players at cadet age five tests for motor abilities, three specific plyometric tests and two specific ball manipulation tests had been selected. The following was tested:

- Acceleration at 20 meters expressed in seconds.
- Speed of change of direction and movement direction in expressed in seconds.
- Speed of change of direction and movement direction with the aspects of aerobic endurance expressed in seconds.
- Maximum height of high jump expressed in centimetres.
- Maximum height of jump with both legs upon landing with two contacts expressed in centimetres.
- Maximum length of long jump (both legs).
- Maximum height of jump with both legs upon landing in one contact expressed in centimetres.
- Maximum height of high jump, single dominant leg, with approach run, expressed in centimetres.
- Ball manipulation speed, speed of arms.

Battery of tests consisted of standardized tests which had already been applied in earlier research regarding energy – motor abilities of athletes. The tests were divided into two groups: *Basic tests* and *Specific tests*: **M20V** – running, 20 m with high start; **TT** – T-test; **KAMIK**–kamikaze; **ST**– Vertical jump–Sargeant test; **MSDM** – long jump; **S2K** – high jump with both legs with two contacts; **S1K** – high jump with landing with one contact, **SZ** – high jump single leg with approach; **DLSL**-Double leg - single leg; **KRKOLJ** – ball circles around knees.

Instructions for performing basic tests are standard whereas the instructions for specific tests had been explained as elements of basketball play for all three elements respectively. Regarding the fact that *high jump with both legs with two contacts* and *high jump single leg with approach* are common movement in basketball, participants – basketball players had been instructed to jump naturally as in the course of game. In case of *high jump with both with two contacts* it was stressed out that it is necessary to step out with one leg and after pulling the other leg to perform high jump, using arm swing. It was also mentioned that choice of leg used in stepping out depends on style or individual habits of participants. In case of *high jump with landing with one contact* it was stressed out that landing is performed on both legs simultaneously and that the jump is high jump with legs in parallel. Regarding the test *high jump single leg with approach* it was stressed out that the jump is performed with a few steps of approach. Approach was to be performed under the angle of roughly 40° relative to the head line. It was also possible to use the leg swing in the course of jump.

Statistical analysis

Data was processed using program package *Statistica 10 for PC*, and statistical parameters were obtained. T-test was used for the purpose of establishing the differences between two groups of basketball players at univariate level (test for independent samples) with error margin $p < 0.05$; differences in the researched area at multivariate level were established using the discriminative analysis.

RESULTS

Difference between the parameters between the players of cadet basketball team of Bosnia and Herzegovina previously divided into two groups – outside and inside positions was calculated using Student T-test for independent samples.

Table 1. T-tests; Grouping: iplayers (CADETS) Group 1: van Group 2: unt

Var.	Mean - van	Mean - unt	t-value	df	p
M20V	3.20	3.33	-2.29	14	0.026
TT	10.08	10.40	-2.68	14	0.009
KAMIK	29.56	30.11	-0.84	14	0.403
ST	54.90	48.83	2.91	14	0.005
SZ	72.90	68.50	1.58	14	0.119
MSDM	241.80	231.50	1.97	14	0.054
S1K	54.20	48.50	2.38	14	0.021
S2K	61.10	55.50	2.14	14	0.037
DLSL	44.50	38.66	3.37	14	0.001
KRKOLJ	61.10	55.50	2.14	14	0.037

Legend: Mean vanjski- arithmetic mean of group of players at outside positions; Mean unutrašnji – arithmetic mean of group of players at inside positions; t value– value of coefficient of t-test used for testing the significance of differences; Df – degrees of liberty; p– coefficient of significance of differences of arithmetic means.

Upon the inspection of Table 1 where the results of Student t-test for calculation of differences between two groups of basketball players in motor abilities are presented we may draw a conclusion that there is a statistically significant difference in seven out of ten tested variables. We may conclude that players at outside positions scored better results than players at inside positions in tests of speed, agility, plyometrics and anaerobic endurance.

Table 2. Discriminative analysis

	Eigen- - val	Canonicl - R	Wilk's - Lambda	Chi-Sqr	df	Sig.
0	0.516	0.583	0.659	17.285	9.00	0.04

In Table 2 are presented the results of discriminative analysis where one statistically significant discriminative function was observed (Wilks' Lambda 0.65) which explains around 58% of variance of discriminative area with degree of liberty of df=9 which provides significance of differences at level Sig=.04 between the two groups of basketball players (players at inside and outside positions) in motor abilities.

DISCUSSION

Obtained results suggest that basketball players who play on inside and outside positions are different in frontal and combined frontal-lateral change of direction, explosive strength and ball manipulation speed. Cause of the aforementioned may be in better motoric control of players who play in outside positions; their movement technique must be better due to their tasks in the game and who have greater body weight (Erčulj, Bračič, & Jakovljević, 2011) whose tasks in the game are less demanding in terms of motoric control. Second reason may be in the biological growth and development, in other words, reasons may be of anthropological nature. Cadets are in the period of life when they still grow, sensitive phases in that period are still different on individual basis; some complete the growth phase earlier, some later, and therefore sensor-motoric function is corrupted as well as body coordination. One of the reasons of the established difference, especially in terms of specific plyometric tests and ball manipulation may be found in motoric control and level of adoption of the technique of movement and ball manipulation. Players playing wing position are more accurate, more agile, and faster and they often find their place at outside positions. They are more active, their technical and tactical units are directed to the immediate proximity of the basket. Analysing the basketball players (Erčulj et al., 2008; Marinković, 2010; Sindik& Jukić, 2011) it was established that players at wing positions have both characteristics of defence players and centre players and their movements are conceptualised more towards front line and often in organising counter strikes. According to Miller (In Matković, Matković, & Knjaz, 2005) wing players spend most of their time in action. In the paper by Knjaz & Kolovrat motor abilities of two top playmakers different in height were tested. Shorter playmaker was 186 cm tall, taller playmaker was 198 cm tall. In plyometric explosive strength they were not significantly different, neither in speed, flexibility, agility, repetitive and specific basketball test. In test of explosive strength of shoulders and arms there was significant difference in favour of taller playmaker, probably due to length of arms and upper body strength. Second relevant difference is in specific speed endurance at 300 yards where 5 s difference was manifested in favour of shorter playmaker. Comparison of results showed no significant differences in their motor abilities but it was emphasised that possession of all these abilities is no guarantee of success in basketball. These motor abilities do not guarantee all the playmakers to be top in the game but are one of the conditions for playing that position in top-level basketball. High-quality playmaker must have the abilities, qualities and knowledge but one thing that separates good playmakers from top playmakers is gift, regardless of the amount of knowledge and ability. As this test was performed on small but representative sample, obtained results may be used as default model of values for the tests themselves and these values can be used in the future for better orientation and for the purpose of comparison of the players' results in general but also by the age and position in the team.

CONCLUSION

Obtained results for the differences between the two groups of basketball players showed statistically significant differences in favour of players at outside positions in the cadet team of Bosnia and Herzegovina in all the performed tests. Significant differences were established in two specific plyometric tests (S2K and S1K). Players at outside positions achieved better results in two of the tests in comparison to players at inside positions. Upon performed analysis of the results it was therefore established that by application of these two specific tests or one of them certain differences in quality of motoric space may be determined depending on the position of the player in the team. We were able to observe from this research that players at outside positions had better results in the tests for assessment of speed, agility and ball manipulation which was expected due to their body constitution and specific training process. Lower height allows players at outside positions to be more agile and swift and therefore the results were in their favour. We may observe for the players at outside positions that they had better results in the tests of explosive strength of lower-body limbs which was expected due to their weight and tasks in the game. This research may contribute better follow-up, planning and programming of basketball training, especially specific individual training whose concept depends of position of the player in the team or as comparison point to a similar research in the field of motor abilities; it can also be repeated on the same sample in order to establish whether there is improvement or stagnation in the area of motor abilities. Data gathered in this research may also be useful from the aspect of individual follow-up of basketball players, establishing their current shape and for prediction of results.

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DIFFERENCES IN GROSS MOTOR COORDINATION BETWEEN CHILDREN SPECIALIZING IN SOCCER AND THEIR PEERS

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SUMMARY

The early detection and continuous monitoring of children's motor competence levels is very important. The purpose of this study was to determine the differences in motor coordination of children engaged in soccer and their peers. One hundred and fifteen boys and girls participated in this study (mean age 8.60±0.85 years). The total sample of subject was composed of two sub-groups: children who do not exercise additionally (N = 65), and children training soccer (N = 50). Motor coordination was evaluated with the Kiphard-Schilling body coordination test (KTK). T test showed significant differences in values of total motor quotient of children in two different groups. When we look for the results of each of the test separately the significant differences ($p<0.05$) between groups can be seen for the balance test and lateral transposition. The other two tests showed no significant differences ($p>0.05$) between children engaged in soccer and children who are not engaged in organized exercise. In conclusion, spending more hours in sports per week has positive effect on gross motor coordination from as young an age as 7–9 years.

Keywords: motor competence, children, football, difference

INTRODUCTION

Lopes, Stodden, Bianchi, Maia, & Rodrigues, (2012) consider motor coordination as one of the most important abilities in early childhood. The aforementioned authors stated that development of motor coordination should be a key strategy in childhood with aim to promote long-term obesity prevention and physical activity promotion. Moreover, it has been found that fundamental movement skills are positively associated with health benefits and increased physical activity (Lubans et al., 2010). Therefore, the early detection and continuous monitoring of children's motor competence levels is very important. There is great variation in motor coordination levels within a general children population. Accordingly, normative standards are important, but also determination of possible differences between different kind of physical activities and its impact on motor competence.

Studies showed positive impact of various exercise programs on motor competence in children compared to free play activities or regular curriculum in kindergartens or schools (Vanetsanou & Kambas, 2010; Morgan et al., 2013). In one cross-cultural comparison of motor competence levels (KTK) in children, Bardid, Rudd, Lenoir, Polman, & Barnett, (2015) showed that Belgian children scored generally higher on motor competence than Australian children. There is a need to investigate the role of different types of physical activity and fitness on motor competence and also how this impact the cross-cultural differences. The purpose of this study was to determine the differences in motor coordination of children engaged in soccer and their peers.

METHODS

Subjects

One hundred and fifteen boys and girls participated in this study (mean age 8.60±0.85 years). The total sample of subject was composed of two sub-groups: children who do not exercise additionally (N = 65), and children training soccer (N = 50). Children who are not involved in an organized physical activity besides the regular system of preschool education are considered as children that do not exercise. Children in soccer clubs are exercising 3-4 times a week for 45-60 minutes. Training consists of specific soccer practice and a relatively large proportion of running and tasks with the ball. Average duration of a child's training process prior to testing was 15 months of exercising in sport clubs. All participants and their legal guardian provided informed and written consent before participation. Ethics approval was obtained from the University Ethics Board at the Faculty of sport and physical education in Novi Sad.

Table 1. Anthropometric characteristics of the studied subjects

	Soccer	No-exercise
Years	8.49±0.90	8.79±0.68
Body height (cm)	128.73±5.85	136.83±5.85
Body mass (kg)	27.11±4.97	32.62±6.72
BMI	16.29±2.31	17.34±2.91

Procedure

Stature and body mass were measured using a stadiometer and a scale according to standardized procedures. Values were recorded to the nearest 0.1 cm and 100 g, respectively. Body mass index (BMI) was calculated [BMI = weight (kg)/height (m2)].

Motor coordination was evaluated with the Kiphard-Schilling body coordination test (Kiphard EJ, Schilling, 1974), Körperkoordination-Testfür-Kinder (KTK), developed and validated on German Children. The KTK includes the assessment of the following items:

- Balance – child walks backward on a balance beam 3 m in length, but of decreasing widths: 6 cm, 4.5 cm, 3 cm.
- Lateral jumps – the child is instructed to hop on one foot at a time over a stack of foam squares. After a successful hop with each foot, the height is increased by adding a square (50 cm × 20 cm × 5 cm).
- Jumping laterally – child makes consecutive jumps from side to side over a small beam (60 cm × 4 cm × 2 cm) as fast as possible for 15 s.
- Shifting platforms – child begins by standing with both feet on one platform (25 cm × 25 cm × 2 cm supported on four legs 3.7 cm high); places the second platform alongside the first and steps on to it; the first platform is then placed alongside the second and the child steps on to it; the sequence continues for 20 s.

The "motor quotient" (MQ), a global indicator of MC adjusted for age and gender, was calculated using the four items and used as indicator of MC. The MQ allows an assessment of the gross motor development in the following categories: 'not possible' (MQ < 56), 'severe motor disorder' (MQ 56–70, percentile 0–2), 'moderate motor disorder' (MQ 71–85, percentile 3–16), 'normal' (MQ 86–115, percentile 17–84), 'good' (MQ 116–130, percentile 85–98) and 'high' (MQ 131–145, percentile 99–100).

Statistical analysis

Data was processed with the Statistica 23.0. software package (Statsoft, Inc., Tulsa, OK, USA). Differences between groups of children who do not exercise and the children enrolled in soccer programs were determined using T test. The level of significance was set at $p < 0.05$.

RESULTS

T test showed significant differences in values of total motor quotient of children in two different groups (Table 2).

Table 2. Results of motor coordination tests in children engaged in soccer and children who are not engaged in organized exercise (mean ± SD)

	Soccer	No-exercise	p value
Balance	47.48±10.94*	33.03±13.95	0.001
Jumps on one leg	45.20±10.57	44.44±15.76	0.78
Lateral jumps	54.24±11.13	52.73±11.03	0.50
Shifting platforms	36.34±4.59*	40.38±5.83	0.01
Total MQ	100.51± 15.07*	93.50±14.95	0.02

When we look for the results of each of the test separately the significant differences ($p<0.05$) between groups can be seen for the balance test and lateral transposition (Table 2). The other two tests showed no significant differences ($p>0.05$) between children engaged in soccer and children who are not engaged in organized exercise.

DISCUSSION

The purpose of this study was to determine the differences in motor coordination of children engaged in soccer and children who are not engaged in organized exercise. The main results of this study are that children enrolled in soccer exercise program have significantly higher levels of motor competence than children who do not exercise. Higher values of total motor quotient in children enrolled in soccer program, shows the exposure to multilateral environment and not only exercise specialised in soccer. This activities seems to be important and very useful for learning and improving motor competence of children.

Gallahue & Ozmun, (1998) stated that children can normally develop one good form of motor competence, but the best form of motor skills can be achieved with the appropriate training. Moreover, the delay in children's motor performance could occur if children do not learn motor skills or do not have the appropriate amount of activity and exercise (Goodway & Branta, 2003). Our study shows similar data, organized physical activity encourage adequate motor development of children. One more important benefit of good coordination is that excellent motor coordination in combination with a well-developed physical fitness in sport seem to be important factor in the development of elite athletic performance (Fransen et al, 2012). Salaj try to find out how fundamental movement skills of preschoolers are developing depending on different exercise programs. They stated that multi-sport programs can be recommended as the best form of exercise for preschool children with certain advantages over specific programs of rhythmic gymnastics and soccer. This was confirmed by Fransen et al, (2012) who showed the importance of spending many hours in sports and sampling various sports in the development of gross motor coordination. Our study had no multi-sport group and therefore this could be further examined and considered as limitation in our study.

CONCLUSION

We found that children enrolled in soccer exercise program have significantly higher levels of motor competence than children who are not enrolled in organized physical activity. In conclusion, spending more hours in sports per week has positive effect on gross motor coordination from as young an age as 7–9 years.

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EFFECTS OF DIFFERENT TRAINING PROGRAMS ON THROWING VELOCITY IN HANDBALL-REVIEW

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SUMMARY

Competitive success in handball depends of the numerous factors such as technical skills and tactics, the anthropometric characteristics, and highs levels of force, power, and throwing velocity. The aim of this study was to analyze previous research about training programs that effect on throwing velocity in team handball last ten years and to analyze which training program is the best for improving that one of the most important part of handball, throw. An extensive electronic database search was performed using MEDLINE, ERIC, PubMed, Google Scholar, SCIn-dex and ScienceDirect to identify relevant articles that investigated the effects of various training programs on throwing velocity. Ten studies were analyzed in this review. A challenging aspect of sports training is to maximize training transfer to a complex motion of overarm throwing in team handball.

Keywords: team handball, throwing velocity, handball training, ball velocity, performance

INTRODUCTION

Handball is a complex sport game, which requires maximum intensity efforts in a short period of time (Vila, Manchado, Rodriguez, Abraldes, Alcaraz, & Ferragut, 2012). Competitive success depends of the numerous factors such as technical skills and tactics, the anthropometric characteristics, and highs levels of force, power, and throwing velocity (Hoff, & Almåsbakk, 1995). In team-handball competition, the offensive players try to score a goal utilizing various throwing techniques to avoid obstruction by the oppositing defensive players. This various throwing techniques differ in the lower body movements (with and without run-up or jump) which influence changes in the upper body movements and thus also affect the performance (Wagner, Pfusterschmied, von Duvillard, & Müller, 2011).

The main aim of the offensive handball players is to throw a ball on goal from a position without being tackled or obstructed by the opposing defensive players. In competition, 73-75% of all throws during the game constitute jump throws, followed by the standing throw with run-up (14-18%), penalty throw (6-9%), diving throw (2-4%) and direct free throw (0-1%) (Wagner, & Müller, 2008). This is an important fact becouse the faster the ball is thrown at the goal, the less time defenders and goalkeeper have to save the shot what is important aspect for success. It is well known that there are differences in throwing velocity between men and women. The male throwers threw faster than the female handball players even with correction for the ball weight. van den Tillaar & Ettema (2004) concluded that body characteristics (height, mass and free fat mass) and isometric strength of the upper limb explain the differences in throwing velocity between men and women. Men produce more force and throw faster because they are taller. That mean that the velocity of a handball throw is not only dependent on the muscular strength but also on other aspects such as body segments coordination and technical skills.

Considering that the throwing ball velocity indicated results at the handball competition its important for coaches to know how to improve it and make better results of its team. That topic has attracted the interest of the scientific communuty. Since 2008 up to now there have been only a few articles about improving throwing ball velocity in team handball with different training programs (core training, heavy resistance training, moderate load training, plyometric, specific strenght and medicine ball training).

The aim of this study was to analyze previous research about training programs that effect on throwing velocity in team handball last ten years and to analyze which training program is the best for improving that one of the most important part of handball throw.

METHODS

Search strategy

An extensive electronic database search was performedusing MEDLINE, ERIC, PubMed, Google Scholar, SCIn-dex and ScienceDirect to identify relevant articles that investigated the effects of various training programs on throwing velocity. A manual search was performed using a combination of the following key terms: handball, team handball training, ball velocity, throwing, throwing velocity, improvement, increases, performance, plyometric training, core training, resistance training, medicine ball training, specific handball training, female, women, male, men, elite handball players. The reference lists of each included article were alsoscanned to identify additional relevant studies. The data-base search was limited to peer-reviewed journal articles published in English between 2008 and 2018.

The electronic searches, identification, screening and data extraction were conducted by one reviewer (KM). This systematic review was undertaken in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Anal-yses (PRISMA) statement (Figure 1.), (Moher, Liberati, Tetzlaff, & Altman, 2009).

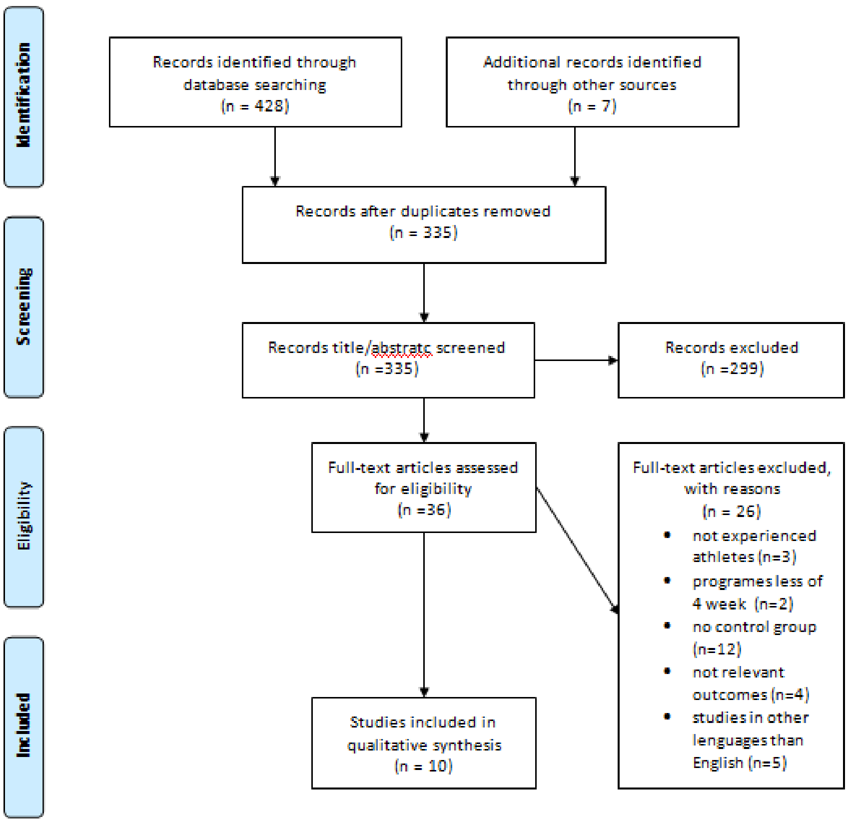
Inclusion Criteria

This review included randomised and non-randomisedcontrolled trials written in English and published within the last 10 years. The included participants were healthy experienced (minimum 5 years of practicing handball) or elite athletes of any age (no restriction). To be included in the review, training programs for imroving throwing velocity were required to be a minimum of 4 weeks in duration and include a control group. The control groups either participated in a general sports programme without intervention training or did not exercise. The included articles were required to report handball throwing velocity as the outcome measure during one or more of the following movement patterns: standing (penalty) throw, running throw, jump shot.

Exclusion Criteria

The exclusion criteria were as follows: (1) studies without a control group; (2) studies written in languages other than English; (3) uncontrolled and cross-sectional studies.

Figure 1. PRISMA 2009 Flow Diagram



RESULTS

Table 1 Systematic review and characteristics of included studies selected for relevant outcomes

Study	Population						Training programme					Outcomes		
	Level	Gender	Age (yr)	Sample size	Drop out (*n*)	Duration (weeks)	Comparison group (*n*)	Type of throwing training	Days/wk	Session (min)	Type of excesis training	ST/P ($m \cdot s^{-1}$)	STR ($m \cdot s^{-1}$)	JST ($m \cdot s^{-1}$)
Ettema et al., 2008	Sports club	F	18.1± 2.1	13	6	8	TG (n=7)	Resistance training	3	-	PD	TG: 1.4 %↑		3,62
Hermass et al., 2010	Elite	M	20.0 ± 06	26	0	10	TG_1 (n=9) TG_2 (n=9)	TG_1Heavy resistance TG_2Moderate resistance	2	120	pull-over and bench press	TG_1: 34 %↑*	TG_1: 42%↑*	
Hermass et al., 2011a	National	M	21.0± 1.9	24	0	8	TG (n=12)	Heavy resistance training	2	90-120	pull-over and bench press	TG :17.7 %↑*	TG :19.4 %↑*	TG :17.6 %↑*
Seatebakken et al., 2011	Sports club	F	16.6 ± 0.3	28	4	6	TG (n=14)	Specific core stability training	2	75	6 specific core and rotational stability exercises	TG:4.9 %↑*		
Van den Tilaar & Marques, 2011	Sports club	F	19.9± 2.1	20	9	8	TG (n=11)	Resistance training	3	40-60	Ball (over/underweight), PD	TG:2.8 %↑		
Chelly et al., 2014	Top-level	M	17.4± 0.5	23	0	8	TG (n=12)	Plyometric training	2	45	Dinamic push-up	TG :23.6±10.7 %↑*	TG:21.0±6.7 %↑*	TG:20.0±9.9%↑*
Hermass et al., 2015c	Elite	M	18.0± 0.5	36	2	8	TG_1(n=12) TG_2(n=12)	TG_1Resistance training TG_2Regular throwing training	3	35	TG_1Medicine ball TG_2Various throwing with regular ball	TG_1:24.2%↑*	TG_1:22.4%↑*	TG_1:22.1%↑* TG_2:16.7%↑*
Reader et al., 2015	Sports club	F	20.8 ± 3.3	28	0	6	TG (n=15)	Resistance training	3		Medicine ball	TG: 14%↑*		
Sabido et al., 2016	Sports club	M	17.2± 0.6	28	0	4	TG_1(n=11) TG_2(n=12)	Resistance training	2		Bench press throw exercise TG_1 Know loads TG_2Unkow loads	TG_2:4.7%↑		TG_2:5.3%↑
Mauchado et al., 2017	Sports club	M	18.7± 3.4	30	0	10	TG (n=15)	Specific core training	4	10-25	Stability exercises using a Swiss	TG: 5.12 %↑ TG(+GK): 5.16%↑	TG: 4.8 %↑ TG(+GK): 3.7%↑	TG: 4.0%↑ TG(+GK): 4.9%↑

Study	Population					Training programme						Outcomes		
	Level	Gender	Age (yr)	Sample size	Drop out (n)	Duration (weeks)	Comparison group (n)	Type of throwing training	Days/wk	Session (min)	Type of excesise training	ST/P ($m \cdot s^{-1}$)	STR ($m \cdot s^{-1}$)	JST ($m \cdot s^{-1}$)
											ball			

↑* - significant increase; ↑ - increase; **%**- change in percent; **F** – female; **M –** male; **PD -** bouts on the pulley device mimicking throwing kinematics at 85% of 1RM squat jump; **ST/P -** standing throw/penalty; **STR -** standing throw with run-up; **JS** - jump shot; **GK** - goal keeper; **TG** – treated group **WK** – week; **±** - standard deviation

DISCUSSION

In the analyzed studies there were three papers which consisted of only women as participants (Ettema, Gløsen, & van den Tillaar, 2008; Van den Tillaar, & Marques, 2011; Chelly, Hermassi, Aouadi, & Shephard, 2014;) while in all other papers the sample of participants involved male participants (Hermassi, Chelly, Fathloun, & Shephard, 2010; Hermassi, Chelly, Tabka, Shephard, & Chamari, 2011; Saeterbakken, Van den Tillaar, & Seiler, 2011; Hermassi, Van den Tillaar, Khlifa, Chelly, & Chamari, 2015; Raeder, Fernandez-Fernandez, & Ferrauti, 2015; Sabido, Hernández-Davó, Botella, & Moya, 2016; Manchado, García-Ruiz, Cortell-Tormo, & Tortosa-Martínez, 2017). The age of participants ranged from 17.2 to 23.3 years old.

There were high level, experienced and elite participants in the all analysed studies, what means that all the paricipants had our trainings per week,, at least and all of them were professional handball players. Four studies consisted resistance treining as an experimental programme (Ettema et al., 2008; Reader et al., 2015; Hermassi et al., 2015), three studies analysed influence of heavy resistance training (Hermassi et al., 2010; Hermassi et al., 2011; Van den Tillar & Marques, 2011; Sabido et al., 2016) and specific core stability trainings were analysed in two studies (Saeterbakken et al., 2011; Manchado et al., 2017), at least just one study analyzed influence of plyometric training on throwing ball velocity in team handball (Chelly et al., 2014).

Throwing is a fundamental skill where two basic factors influence the efficiency of shots: accuracy and throwing velocity. The faster the ball is thrown, the less time defenders have to save the shot. Handball coaches and scientists seem agreed that the main determinants of throwing velocity are technique, the timing of movement in consecutive body segments, and the strength and power of both the upper and lower limbs (Gorostiaga, Granados, Ibanez, & Izquierdo, 2005). In case to improve efficiency of throwing the authors made different training programs and tasted it with different and most common throwing techniques in handball such as throwing with one hand (overhead throwing) from a standing position called standing throw which involves keeping the lead foot on the floor during the throw and is typical for the penalty throw in team-handball, then standing throw with run-up where one foot is planted on the floor after run-up and the last one is the jump throw which has performed with one leg at vertical take-off and has phase of the flight. Only Ettema et al. (2008) used different mesurement protokol than other useing heavier/lighter ball then regular and regular ball for estimating throwing velocity. In the study with female participants who did specific resistance training, which was designed to mimic the handball throwing movements as closely as possible, does not show a stronger effect than training the performance exercise (in this case throwing regular weighted handballs) (Ettema et al., 2008). The authors Ettema et al. (2008) oppinion is that the programe has succeeded in this from a kinematic point of view but there isn't data to comfirm this ascertainment. The training protocols for strenhgt improvement consist exercises with medicine balls (heavier balls of regulr ball) which demonstrated beneficial carryover effects on throwing velocity in handball (Reader et al., 2015; Hermassi et al., 2015). The performance of throwing velocity, isokinetic strength of the shoulder rotators in female handball players could be significantly improved using 6 weeks of periodized medicine ball training, whereas throwing precision remained unaffected (Reader et al., 2015). The present medicine ball training allows exercises to be performed at relatively high speeds, compared with classical strength training using free weights or machines, but with greater force than those performed during normal sport competition. Sport-specific explosive movements in either the transverse or oblique planes eliciting movement-specific adaptations with an increased amount of specific angular velocity from the proximal to the distal body segments until the release of the ball (Reader et al., 2015).

Exercise such as pull-over, bench press were used in study Hermassi et al. (2011) and after 8 weeks of training have shown significant results in throwing velocity in all three types of throwing techniques. This findings provides to others researchers and coaches good base for the future developing in makeing good heavy resistence training programme for elite, in this case male, handball players, but with some changes it can be used for female, too. Moreover, Hermassi et al. (2010) proved that moderate resistance training (around 70% 1RM) showing significant increments of upper limb muscle volume relative to heavy resistance training and also increases regional muscule volume. Sabido et al. (2016) have proved that the use of unknown loads has led to greater gains in power output in the early time intervals as well as to increases in throwing velocity compared with known loads. Therefore unknown loads are of significant practical use to increase both strength and in-field performance in a short period of training in elite junior male handball players. In the study Van den Tillar & Marques (2011) after the heavy resistance training period was no found increase in ball velocity in female handball players. The reason that the ball velocity did not increase could be due to the ineffective use of the wrist and finger flexions that were not studied in this study.

Seatebakken et al. (2011) study purpose was to investigate the effects of a core stability training program on maximal velocity among handball players. A low-volume, high-intensity core-training regime was employed. The experimental group showed a ~5% improvement in maximal throwing velocity, whereas the control group did not change. The increase in throwing velocity of the experimental core stability training group might be explained by an increase lumbopelvic rotational stability and strength. Another study with the similar purpose was was to explore the effect of a training program aimed at strengthening the muscles in the lumbo-pelvic region by means of exercises focused on improving the kinetics of movement in handball players' throwing velocity. The results showed an improvement in male handball players' throwing velocity, after an 8 week period of core training, fout ime per week (Manchado et al., 2017).

Useing of plyometric training program can also improve throwing velocity in male handball players. The substitution of other activities by biweekly in duration 8 weeks periods of in-season plyometric training enhanced the peak power of both upper and lower limbs, whether assessed by jumping, sprinting, a cycle ergometer force-velocity test, or throwing velocities (Chelly et al., 2014). The experimental group in this study didn't increase the total training time just replaced some regular exercises with plyometric exercises. For upper limb push-ups were performed and outcomes were positive.

CONCLUSION

Overarm throwing is a complex motion, which depends on several components (i.e., technique, strength and power, and a proper kinetic chain), (Chelly, Hermassi, & Shephard, 2010). A challenging aspect of sports training is to maximize training transfer to all those components.

The goal of the exercise selection and muscular load range in the mostly of studies was to improve performance in a movement requiring very high levels of muscle recruitment. For example, a unique functional, 3D, core stability program consisting of progressively unstable closed kinetic chain exercises for hips and torso significantly improves throwing velocity among handball players. High levels of core strength and stability may be an important precondition for generating high rotational velocities in multisegmental movements such as throwing (Seatebakken et al., 2011). Core training program has significant potential benefits such as improvement in static and dynamic balance, injury prevention and mainly improvement in throwing velocity. It is advisable for coaches and handball players to practice it merely 10 to 15 minutes per training. As well, a progressive program for strengthening and training the lumbo-pelvic region in order to improve stability and kinetics of movement seems to be related to an increase in handball players' throwing velocity and it would seem highly advisable to implement strength training programs in handball training and in team sports in general.

Some authors find that the high velocity plyometric trainings may improve the rate of force development relative to traditional weight training (Herrero, Izquierdo, Maffiuletti, & Garcia-Lopez, 2006). In the handball sport the first and, for now, uniqe objective demonstration of plyometrics training value was found in Chelly et al. (2014) study. The results of plyometic exercise were positive in all mesuring aspects of elite handball playerses performance. Recommendation for future studies is observation of plyometric treining to other levels of competition, to women and to other ages group with investigation of differing intensities and volumes of plyometric training to determine their optimum dosage for this form of preparation. Therefore, handball coaches should, also, implement in-season plyometric treining to enhance the performance of their players.

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JUNIORS VS SENIORS SHOOTING-PARAMETERS DIFFERENCES IN REGIONAL LEVEL BASKETBALL PLAYERS

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SUMMARY

The aim of this research was to examine shooting-parameter differences (entry angle and release time) between basketball junior and senior players and compare results with normative value. Eighteen perimeter male basketball players divided into Junior (age=17.37±0.65, height=195.1±5.0 cm, 7.1±2.3 years of training experience), and Senior (age=25.62±2.45, height=194.2±8.4cm, 11±2.9 years of training experience) age group were recruited for the study. Every player got 3 series of 5 three point- shots, with a shot-entry difference for every set: 1. spot shot, 2. after 2 forward steps or 3. after one dribble. Mann-Whitney test was used to analyze the difference between groups. Seniors had significantly higher entry angle than Juniors (41.21°±2.97 vs 38.53°±4.07; p=0.000) for all shots. Seniors also had significantly higher entry angle difference for set 2 and 3 independently, but not for set 1. Release time was statistically lower in seniors for all shots (0.90s±0.17 vs 0.87s±0.20 for Juniors and Seniors, respectively) as well as for set 3 independently (0.91s±0.09 vs 0.87s±0.16 for Juniors and Seniors, respectively). It is likely that shooting quality is related to player's quality level and training experience.

Key words: entry angle, shot release speed, basketball shot, 94Fifty®.

INTRODUCTION

To play successfully, basketball players must possess optimally developed physical fitness in multiple dimensions, including aerobic capacity, anaerobic power, upper-body and lower-body power (Abdelkrim et al., 2010). In addition, basketball players must possess excellent techniques such as shooting, jumping, passing, and dribbling. It is generaly accepted that shooting performance is one of the most important determinants of succes in basketball (Okazaki et al, 2007). Furthermore , four factors of basketball succes- shooting percentage, turnovers, offensive rebounding and free throw percentage, are frequently named crucial in basketball science and practice (Oliver, 2004), with shooting regularly proclamed as the most important one. Success in basketball depends on the ability to project the ball through the basket, and the skill of shooting has been recognized as one of the most important elements in the game (Hay, 1987). Consequently, previous studies have examined the importance of different types of shooting (free throws, the 3-point shot) on the overall success in basketball, with the jump shot found to be most efficient shooting technique (Pojskic et al., 2009). Jump shot is one of the most frequently used method of shooting in modern basketball. In Spanish league, 41% of all shots are jump shots (Rojas et al., 2000). Certain parameters of the shot are considered crucial to bring this technical element to the perfection. The optimal jump shot requires a backspin rotation, release velocity and release-dependent entry angle (Knudson, 1993). These elements require a proper execution, a ball held above the forehead, an elbow with an angle of 90 degrees, the wrist of the hand raised but relaxed. Ideally, the ball would leave the hand after half a second from the moment the ball was received, at the highest point of the jump (Knudson, 1993). Release angle and entry angle are directly related one to another (Brancazio, 1984), but are also dependent on the distance from the basket. As the distance increases, the player has to reduce the angle, he need to shot with lower release angle (Miller & Bartlett, 1996) which reduced the entry angle but also the energy cost required for an increased ball velocity.

The key for successful shooting is to develop consistent movement techniques, permitting an optimal release angle that can be adjusted according to shot distance and fatigue level. It is well established that specific sport techniques, such as shooting, vary as a function of time, competitive standard, and playing experience (Shakespear, 1997; Stratford, 1984). Regarding experience, a greater speed of the ball at release and greater accuracy has been reported in experienced field hockey and soccer players compared with recreational players (Anderson & Sidaway, 1994; Kerr & Ness, 2006). However, considering basketball, those information's are lacking. Studies have examined intervention related to shooting (Oudejans et al., 2012; Slawinski, 2018), biomechanical and proprioception parameters of shooting performance (Miller & Bartlett, 1993; Miller & Bartlett, 1996), and even nutritional interventions and their influence on shooting achievements (Dougherty et al, 2006; Baker et al., 2007). However, shooting-related parameter differences in various age groups, to the best of our knowledge, has not been reported. Consequently, the aim of the present study was to examine shooting-parameter differences (entry angle and release time) between basketball junior and senior regional level basketball players and compare results with normative value. It was hypothesized that senior players would demonstrate a better technique than junior players.

METHODS

Subjects

Study included 18 perimeter male basketball players (age 21.5, high 194.82±7.1 cm, and average training experience of 8.8 ± 2.4 years), members of BC "Vojvodina" from Novi Sad, team in the highest national ranking (first division, Serbia). We included only perimeter players (i.e., positions 1, 2, and 3) in this study because of their well-known proficiency in different types of shooting (i.e., short-, middle-, and longdistance shooting performances) (Sindik & Jukic, 2011). The first group (Juniors) consists of 9 players from the junior team, (age of 17.37, high 195.1±5.0 cm, and average training experience of 7.1 ± 2.3 years). They compete in Junior league of Serbia. The second group (Seniors) consists of 9 senior team players (age 25.62, high 194.2±8.4 cm, and average training experience of 11 ± 2.9 years). All tested players train more than 4 years. All players had competed at the national level, and they were required to have played in at least 10 games for at least 15 minutes per game during the last season to enroll the study. All were healthy without reported injuries in the previous 6 months. They trained 7,5 hours a week (5 sessions of 1,5 hours each) on the court to improve technical and tactical skills They also played a basketball game every Saturday or Sunday. Participants were asked to refrain from heavy training, alcohol, tabacco and caffeine use and to avoid sleep deprivation for at least 2 days before the testing sessions. All players are familiar with the purpose of the research and have accepted to participate in the study.

Procedure

94Fifty smart sensor basketball (InfoMotion Sports Technologies, Inc.) was used to measure shooting-parameterst and interpret results. 94Fifty is “SMART” ball which have identical dimensions like regular ball size 7 for basketball. It contains sensors that measure certain parameters and displays this data by application on smartphone. Parameters that were obtained are entry angle and release velocity (angle at which the ball enters into the basket, and speed of performing the shot). Recommended intervals for these kinematic parameters: release time below 0.7 s, and entry angle from 42° to 48°.Prior to testing, standard warm up was carried out (5 min jogging +5 minutes dynamic warm up), and each respondent had 5 trial shots, which were not recorded. Test included 3 series of 5 shots for three point (distance of three point line is 6.75 m from the basket), with a 3-minute rest period between each series. No time constraint was placed upon the players, however they were encouraged to shoot immediately after receiving the ball. All three series had different preparation phase: for first five shots player received the ball from the assistant in spot, without moving, and shot immediately after receiving the ball. In second set players had to take two steps toward the three point line, receive the ball, and than took a shot. In last five shots, players received ball about 1.5 m from the three point line, and shot after one dribble towards basket. Players received ball in triple-threat position and immediately proceed with the task – game-like shot or dribble. A total of 270 shots were analyzed, and for each shot information for release speed and entry angle were recorded.

Statistical analysis

Descriptive statistics (mean and SD) were calculated for each variable. Data sets were tested for normality using the Kolmogorov-Smirnov (K-S) after which Mann-Whitney test was used to analyze the difference between the groups because the data in the variables deviated from the normal distribution. The significance for all statistical tests was set at $p < 0.05$. All statistical analyses were completed with the SPSS Ver. 20.0 software statistical package (SPSS Inc., Chicago, IL, USA).

RESULTS

Descriptive statistics for variable entry angle and release speed for two subgroups (mean, standard deviation, Skewness, Kurtosis, min, max, and result of Kolmogorov Smirnov test) were calculated and proved to deviate from normal distribution (Table 1).

Table 1*. Basic descriptive statistics of the entry angle and release velocity for Juniors and Seniors*

	Category			
	Entry angle		**Release velocity**	
	Juniors	**Seniors**	**Juniors**	**Seniors**
AS	38.53	41.21	0.90	0.87
SD	4.077	2.971	0.17	0.20
SKJU	1.458	0.105	1.527	0.93
KURT	5.257	0.017	3.594	1.57
KS	0.000*		0.000*	

Legend: **AS** - arithmetic mean; **SD** - standard deviation; **SKJU** - Skewness; **KURT** - Kurtosis; **KS** - Kolmogorov-Smirnov test; * - statistical significance of deviation from normal distribution (p <0.05)

Table 2.*Significance of the differences between Junior and Senior in parameter entry angle and release velocity for all shots*

		Category						
		Juniors			**Seniors**			
	N	**Mean Rank**	**Mean**	**SD**	**Mean Rank**	**Mean**	**SD**	**Sig.**
Entry angle	270	102.81	38.53	4.07	168.19	41.21	2.97	0.000**
Release velocity	270	144.65	0.90	0.17	126.35	0.87	0.20	0.054

Legend: N - number of respondents; **Mean -** arithmetic mean; **SD -** standard deviation**; Mean Rank**; **Sig -** the level of statistical significance of the difference**; * -** statistical significance of differences (p <0.05); **** -** statistical significance of differences (p <0.01)

Table 3*.The significance of the differences between Junior and Senior in parameter entry angle and release velocity when they were shooting after receiving the ball in one place*

		Category						
		Juniors			**Seniors**			
	N	**Mean Rank**	**Mean**	**SD**	**Mean Rank**	**Mean**	**SD**	**Sig.**
Entry angle	90	33.43	38.93	4.50	57.57	41.29	2.39	0.000**
Release velocity	90	44.01	0.88	0.12	46.99	0.89	0.14	0.588

Legend: N - number of respondents; **Mean -** arithmetic mean; **SD -** standard deviation**; Mean Rank**; **Sig -** the level of statistical significance of the difference**; * -** statistical significance of differences (p <0.05); **** -** statistical significance of differences (p <0.01)

Analysis for a differences in parameters (release velocity and entry angle) between Seniors and Juniors for all shots (Table 2) showed no significant differences between two tested groups in parameter release time (p =0.054) and significantly higher entry angle in seniors vs juniors (p =0.000; 41.21°± 2.97 vs 38.53°± 4.07, respectively).

For first set of shots, immediately after receiving the ball, there were no statistical differences between groups in variable release velocity (p =0.588), but seniors had significantly higher entry level than juniors (p =0.000; 41.29±2.39 vs 38.93± 4.50) (Table 3).

When differences in parameters was analysis for shots after moving (Table 4), group of Senior had significantly higher entry angle than group of Junior (p =0.001; 41.09°±3.32 vs 38.73°±3.95, respectively). In variable release time there is also statistical significant differences in favor of group of Senior (p=0.046; 0.87±0.16 s vs 0.91±0.09 seconds). Seniors has approx result with recommended values from the manufacturer.

***Table 4**.The significance of the differences between Junior and Senior in parameter entry angle and release velocity when they were shooting after two steps towards the ball.*

		Category						
		Juniors			Seniors			
	N	Mean Rank	Mean	SD	Mean Rank	Mean	SD	Sig.
Entry angle	90	36.64	38.73	3.95	54.36	41.09	3.32	0.001**
Release velocity	90	51.00	0.91	0.09	40.00	0.87	0.16	0.046*

Legend: N - number of respondents; **Mean -** arithmetic mean; **SD -** standard deviation**; Mean Rank**; **Sig -** the level of statistical significance of the difference**; * -** statistical significance of differences (p <0.05); **** -** statistical significance of differences (p <0.01)

***Table 5**.The significance of the differences between Junior and Senior in parameter entry angle and release velocity when they were shooting after the dribble towards the basket*

		Category						
		Juniors			Seniors			
	N	Mean Rank	Mean	SD	Mean Rank	Mean	SD	Sig.
Entry angle	90	33.48	37.93	3.75	57.52	41.27	3.17	0.000**
Release velocity	90	51.59	0.92	0.25	39.41	0.85	0.27	0.027*

Legend: N - number of respondents; **Mean -** arithmetic mean; **SD -** standard deviation**; Mean Rank**; **Sig -** the level of statistical significance of the difference**; * -** statistical significance of differences (p <0.05); **** -** statistical significance of differences (p <0.01)

As in the previous analysis, Seniors had significantly better result in variable entry angle than Juniors (p =0.000, 41.27°±3.17 vs 37.93°±3.75, respectively) (Table 5). Seniors had result near recommended values (42° – 48°). For variable release time analysis showed significantly difference in favor of Seniors (p =0.027; 0.85±0.27s vs 0.92±0.92s). Both tested groups had higher result than recommended values given by the manufacturer of the system (<0.7 s).

All the average values of the entry angle of the shot are below the values declared by the manufacturer as the norm. Also, all the average release time of the shot for seniors and juniors of KK "Vojvodina" are lower than the norms given by the ball manufacturer (Nelson, 2015).

DISCUSSION

This study investigated the differences shooting-parameter differences (entry angle and release time) between basketball junior and senior regional level basketball players and compare results with normative value. The main finding of this research proved statistically significant differences between two subgroups of player in parameter of shot – entry angle in all three different preparations for the shot. Thus, Senior players have higher release angle and entry angle which is in line with some previous research (Okazaki & Rodacki, 2012, Okazaki, 2015). Previous study showed that players with poorer shooting technique have lower entry angle compared to players with advanced technique (Lenik & Lenik, 2016). It can be speculated that Seniors have superior shooting technique, which is likely result of training years (average training experience of Seniors is 11 ± 2.9 and Juniors 7.1 ± 2.3 years). In aditiion, it is likely that the Seniors are physically fitter than Juniors, with fitness proved to be significant determinant of shooting performance, especially from a distance (Justin et al, 2006). Indeed, the existence of a positive relationship between studied physical capacities and specific basketball shooting performance with stronger relationships for dynamic shooting tests was recently presented (Pojskic et al., 2018). Moreover, this assumption is in agreement with the results of the study by Pojskic et al. (Pojskic et al., 2011), who reported a positive relationship between vertical jump performance and 3-point shooting accuracy during one competitive season.

Analyzing the results of release velocity parameter, it can be noticed that the data is changed depending on the preparation for the shot. For release velocity of great importance is way to prepare for a shot (Mack, 2001; Oudejans et al., 2012; Theodorakis, 2001) as well as the conditions of the game and position of the defending player (Rojas et al., 2000) and distance from the basket (Miller & Bartlett, 1996). In these research, parameter release velocity is changed in subgroups in relation to the type of preparation for the shot. There is no significant differences between groups when players took a shot immediately after receiving the ball in spot, but there is differences when they are shooting from the movement and after the dribbling, and that difference is increasing as the preparation becomes more demanding. The players from group of Seniors release the ball faster in comparison to Juniors. It can be assumed that shot velocity largely depends on the way of preparation for the shot, quality of receiving the ball as well as dribble quality, all of which represent the basic basketball elements that should be practiced regularly. Also, shot speed is proved to be strength-dependent (Radenković et al., 2018; Pojskic et al., 2018). Training experience of groups can most likely be the overall explanation for study results. With training experience players should be able to execute technique more efficiently and faster, the speed of the shot should increasing as well, especially the preparatory phase for the shot, which represents 60% of the total time of the shot (Podmenik et al., 2017).

CONCLUSION

In conclusion, the present results show a significant effect of playing experience on the kinematic characteristics of the shooting action. Indeed, compared with juniors, senior shooters were characterized by a parameter of the entry angle, and there are differences in the release velocity between these groups. In parameter release velocity these values are not always statistically significant, but there is some differences between groups. The obtained values are not in the range of the recommended values given by the manufacturer, but we can assume that these results were obtained on a top sample of professional basketball player. Future research should be focused on younger age basketball players and/or lower quality level. In this case, this technology could be used even in the training process of younger categories, which would make the learning process easier, and in a very efficient way give information on which parts of the shot players need more practice.

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THE DEVELOPMENT OF EXPLOSIVE STRENGTH OF THE LOWER EXTREMITIES IN VOLLEYBALL PLAYERS

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SUMMARY

The purpose of this paperwork was to collect studies up until now that have dealt with the development of explosive strength in volleyball players. For the collection, classification and analysis of targeted research was used descriptive method and theoretical analysis and research that have been reached are searched on Google Scholar, SCI, PubMed and Kobson. The paper presents 20 research. The results of the research have shown that plyometric training method is the most commonly used for the development of explosive force The results also show that the best effect for the development of explosive power is achieved by combining the plyometric training method and some other training.

Keywords: explosive leg strength, plyometric training, vertical jump, volleyball

INTRODUCTION

In sport and physical education, especially in physical activities with a high percent requirements of the leg muscles, the most important are lower extremities. Overall, they are responsible for the sports that require strength, handball, basketball, volleyball, football, racing sports and other sports with the dominant role of the lower extremities. The most important aspect of the power of the lower extremities, is reflected in the explosive force.

Jump is any separation from the surface by the action of certain muscles, or by the personal effort of the jumper. In sports practice there are many types of jumps: standing jump, long jump, jumping from one or both legs, length or height jumps, vises, jumps in depth, leap, lends (Kraemer, 1996). The intensity of the jump is significantly influenced by the strength of the current musculature, coordination, degree of technique mastering,age

Jump as physical ability is a prerequisite of a successful attack and defense on the net. In this structure of movement jump is energetically the most demanding, and is the most complex way of developing this property, and it is also a readiness to jump and an indicator of overall physical readiness. According to previous studies, the maximum number of jumps that a single volleyball player performs in a match (5 sets) is about 100 jumps for player at the position of the middle blocker, 90 jumps for the corrector, and 70 jumps for the receiver (Dopsaj, 2012).

For movement jump - lend extensors in leg wrists operate in an eccentric regimen against gravitational force and inertia force. In this way, their tendons under the influence of great powers stretch and accumulate in itself a considerable energy that returns to the body in some, concentric phase, and then increases the reflex impulse and jump height (Vassil, 2012).

Plyometry implies exercises that put the current muscle and muscle group in a state of increased stretching before contraction. Plyometry in movements occurs in all cases where eccentric contraction (muscle elongation) is rapidly replaced by concentric contraction (muscle contraction). Muscle elasticity contributes to producing much more power through this cycle than through voluntary contraction. It includes exercises with jumps that after landing are followed by a quick bounce.

Plyometric training uses gravity to rapidly stretch the muscle during the landing to thereby create elastic energy for more efficient implementation of the concentric phase rebound. The main purpose of plyometric training is the development of greater reactive force (Čoh, 2013).

Many researchers have dealt with problems of plyometric training in other sports as well as in volleyball. The purpose of this paperwork was to collect studies up until now that have dealt with the development of explosive strength in volleyball players.

METHODS

The literature search was conducted using the following search engines: Google Scholar, SCI, PubMed and Kobson, searching for keywords: plyometric training, jumping ability, volleyball, explosive leg strenght. Only those works that were published in the period from 2004-2018 year were taken into considerration. In addition, references of all papers were examined for finding additional scientific papers that have studied the same or a similar area.

Table 1 - Development of explosive power

The study, first author, year	The sample			Experimental program			
	The total number	Age	Sex	Duration	Number of groups	Program	Results
Rajić (2004)	N = 11	20	F	4 weeks	1E	Combined training method	A statistically significant improvement in indicators Fmax and Cmax, as well as at the ankle joint (LISTsed) with the following characteristics: ImpFmax (r = 0,045), tFmax (r= 0,004) i Cmax (r= 0,031)
Gabbett (2005)	N= 26	15.5 +/- 0.2	M	8 weeks	1E	Specially designed program according to the gaming position	Considerable improvement in the speed and agility as well as the manifestation of the technique (r<0.05)
Rahimi (2005)	N= 48	19	M	6 weeks	1E 1E 1E 1K	plyometric training, resistance training, plyometrics plus resistance training	The combination training group (plyometric and weight training) shows no improvement in vertical jump performance, at 50 yards, and leg strength in relation to the other two groups
Rahimi (2006)	N= 48	19	M	6 weeks	3E 1K	a group that has a plyometric training group on strength training, a group that has been subjected to a combination of the two types of training	The results showed that all subjects who trained had improvement of angular velocity (p <0.05). However, respondents from the group that had a combined training had significantly greater increase in angular velocity in relation to the other two groups (plyometric and strength training).
Milić (2008)	N= 46	16	M	6 weeks	1E 1K	Plyometric training	A considerable improvement of the monitored parameters in the experimental group
Lehnert, (2009)	N= 11	14	F	8 weeks	1E	Plyometric training	Statistically significant improvement of the monitored parameter
Kostanić, (2012)	N=13	seniors	M	18 weeks	1E	Weight training, plyometric training	Statistically significant change in the vertical jump tests from squatting position (F = 6.85; p = 0.02) and vertical jump with the preparation of (F = 9.86; p = 0.0

Trajković, (2012)	N=16	22.3 ± 3.7	M	6 weeks	1E	Conditioning training	There is no statistically significant improvement in the parameters monitored after experimental treatment
Gortsilla, (2013)	N=45	11.1 ± 0.5	F	10 weeks	4E	Training on sand	Statistically significant improvement of both monitored parameters (r <0.001)
Asadi (2013)	N=20	20	F	6 weeks	1E 1K	Plyometric training	Progress in the experimental group
Váczi, (2013)	N=10	21.3±2.4	F	5 weeks	1E	Plyometric training	Statistically significant improvement in height jump of average 4cm in high jump without a run - up and 5cm in a jump with a run - up
Kramer, (2014)	N=10	19.90±1.60	F	2 months	1E	Static (SS) and Dynamic Stretching (DS)	Dynamic stretching contributed to better jumping performance compared to static
Moreno, (2014)	N=12	23.1±3.4	M	6 weeks	1E	Strength training in the gym	Statistically significant improvement in the height of the jump (p <0.05)
Smída, (2014)	N=14	12 - 15	M	6 weeks	1E	Combined training	Statistically significant improvement of the height of the jump
Mannan, (2015)	N=30	seniori	M	12 weeks	1E 1K	Plyometric training	Statistically significant changes (p <0.05) between initial and final measurements in favor of the experimental group.
Pereira, (2015)	N=20	14	F	8 weeks	1E 1K	Plyometrics; throwing medical and volleyball balls	Explosive power was statistically significantly improved in the experimental group (counter movement jump r = 0.05; throwing of medical and volleyball ball r = 0.00)

Sabin, (2015)	N=12	14	F	9 months	1E	Exercises for the development of agility and balance in the framework of regular technical - tactical training	Statistically significant improvement in agility and balance
Kim, (2016)	N=28	seniors	F	8nedelja	1E 1E	Vibration Training (WBVE), Plyometric Training (PME)	Both experimental groups indicated statistically significant progress in the monitored parameters
Voelzke, (2016)	N=16	seniors	M	5 weeks	1E 1E	Training with resistance + plyometric training; muscle stimulation + plyometric training	The combined training program with resistance and plyometric exercises statistically significantly influenced the improvement of the explosive power of the type of jump, while the muscle stimulation program in combination with the plyometry gave significant results in improving the haste, speed and agility
Sheikh (2018)	N=45	18-22	M	12 weeks	1E 1E 1K	Plyometric training with weight vest, plyometric training without weight vest	Plyometric training with weight vest indicates a significant improvement in speed and agility, in comparison to a training without weight vest

Legenda: N-total number; **E-** experimental group; **K-** control group;

RESULTS

The number of participants varied considerably from research to research so that the smallest number of N = 10 participants was represented in the research (Kruse et al., 2014; Stamm, et al., 2013), and a maximum of 48 (Rahman et al., 2005). In 9 out of 20 studies, the sample of respondents consisted of female volleyball players (Rajić et al., 2004; Lihnert et al., 2009; Kim et al., 2016), while in the other 11 studies, respondents were male (Rahman et al. al., 2005; Gabbett et al., 2006; Milić et al., 2008; Voelzke et al., 2016).

The very structure of the volleyball game is such that even when training is done on technical-tactical preparation, a lot of jumps and changes in the direction of movement are performed, so certain changes after a certain time in athletes are inevitable. With that fact in mind, in addition to the experimental group, there should be a control in order to determine with certainty the efficiency of experimental treatment; in only 7 studies, the entire sample of the subjects was divided into experimental (E) and control (C) groups (Milić et al., 2008; Gortsilla et al., 2013, Mannan et al., 2015, Pereira et al., 2015), where as in the other 13 studies there was only an experimental group (Rajić et al., 2004; 2005, Gabbett et al., 2006; Lihnert et al., 2009). In two studies, respondents were divided into two experimental and one control groups (Rahman et al., 2005; Sheikh et al., 2018), while two experimental groups were also found in two papers (Kim et al., 2016; Voelzke et al., 2016).

Plyometric training, as an experimental treatment, was used in five studies (Milić et al., 2008, Asadi et al., 2013; Mannan et al., 2015). The combined method of training was used in three studies (Rajić et al., 2004, Elif et al., 2010, Smida et al., 2014), while the specially designed program according to the player positions in order to improve the performance of the technique, the development of agility and velocity applied in research by Gabbett et al. In one study, the experimental treatment applied was carried out on sand (Gortsilla et al., 2013). Kruse and his associates (Kruse et al., 2014) applied two types of stretching (static and dynamic) as a method for the development of explosive forces. Strength training at the gym, used (Moreno et al., 2014, Pereira et al., 2015), in his work he examined the effects of plyometric exercises in combination with the practice of throwing the medical and volleyball ball on the development of the explosive power of the lower and upper extremities. Two types of training (full-body vibration training and plyometry) were used in the study (Kim et al., 2016), while the study Voelzke et al. (2016) applied resistance training and plyometric training in one experimental group, while the second experimental group was subjected to a combination of electrostimulation of the muscle and plyometry.

An interesting piece of data that could be obtained by analyzing the collected papers is the length of the duration of experimental treatments that varied from four weeks (Rajić et al., 2004) for up to nine months (Sabin et al., 2015). In the majority of studies - 9, experimental treatment lasted for six weeks (Martel et al., 2005; Milić et al., 2008, Moreno et al., 2014)

It should also be noted that, since it is about basic motor skills, the most adequate period for their development is the preparation period, which is precisely one of the limiting factors when it comes to the length of the experimental treatment, since it is aligned with the different competition calendars .

In all studies, after statistical data processing, the results indicate a statistically significant improvement in the parameters monitored for groups that were subjected to a particular experimental treatment.

DISCUSSION

A large number of studies in Table 1 show that the explosive power of volleyball can be developed using the plyometric training method.

Milić et al. 2008 found that plyometric training leads to an increase in the vertical jump height. **Linhert et al. 2009** found that 8-week plyometric training in which two training exercises were conducted weekly contributes to the improvement of explosive force in the form of a vertiginous jump. **Asadi et al. 2013**, on a sample of 20 female players, found that a 6-week plyometric program, in which the number of exercises and jumps per training increases from weekly and where there is a pause between the series for three minutes, leads to an increase in the vertical jump height. **Stamm et al. 2013** on a sample of 10 female players, found that plyometric training lasting 5 weeks contributes to improving the height of the jump. **Mannan at al. 2015**, on a sample of 30 senior volleyball players, conducted a twelve-week program that contributed to a statistically significant improvement in speed, strength and agility.

In addition to plyometric training combined training has proven to be a good method for developing the explosive power of volleyball players. **Rajić et al. 2004**, on a sample of 11 female volleyball players, aged 20 years, found that the combination of plyometric training and load training for 4 weeks led to a statistically significant improvement in Fmax and Cmax. **Rahman et al. 2005**, on a sample of 48 male players, aged 19, found that a combination of plyometric training and 6 week training exercises led to a significant improvement in the jump in height compared to the group that only performed plyometric training. **Kostanić et al. 2011**, on a sample of 13 volleyball players of senior age, claimed that the combination of plyometric training and weight training for the duration of 18 weeks leads to a significant improvement in the vertical jump height. **Smida et al. 2014**, on a sample of 14 volleyball players aged 12-15 years, combined training for 6 weeks led to a statistically significant improvement in the rebound.

Some studies have shown that in addition to plyometric training, there are other methods of developing explosive power of volleyball. **Kruse et al 2014** on a sample of 10 female players, with an average age of 19.90 ± 1.60 years, found that dynamic stretching contributes to better jumping performance compared to static. **Moreno et al. 2014**, on a sample of 12 volleyball players, 23.1 ± 3.4 years old, found that training in the gym for 6 weeks significantly influenced the improvement of the vertical jump.

Training on sand also leads to a significant development of the explosive power of volleyball players. **Gortsilla et al. 2013** on a sample of 45 volleyball players, found that sand training statistically significantly affects agility improvement.

In addition to the before mentioned, some other methods have proved to be effective in the development of the explosive power of volleyball. **Sabin et al. 2015**, on a sample of 12 volleyball players, aged 14, found that exercises for the development of agility and balance in regular technical-tactical training for a period of 9 months statistically significantly contribute to improving agility and balance. **Kim et al. 2016**, on a sample of 28 female senior volleyball players, determined that vibration training contributes to the development of jumping performance. **Sheikh et al. 2018**, on a sample of 45 volleyball players, found that plyometric exercises where additional external load in the form of a vest is used for a period of 12 weeks lead to a significant improvement in speed and agility.

CONCLUSION

Based on previous research we have seen that for the development of explosive power, the most commonly used is plyometric training method is for both male and female volleyball players. In order to develop this abilities, it is necessary that the training process lasts from 4 to 12 weeks. In most studies, this method of training involved practicing two to three times a week. Considering the author's recommendations, the plyometric method should be used with caution, with prior preparation and development of muscular endurance, in order to avoid injuries and overstretching.

Another method that has proven to be effective for the development of players explosive power is combined training. The authors consider that the combination of the plyometric training method and some other training may be more effective than when plyometric training is used individually.

An overview of the current research shows that, besides mentioned, the explosive power of the lower extremities of the volleyball can also be developed with the help of the following training methods: a combination of plyometric training and some other training (dynamic stretching, strength exercises), weight training, plyometric training with additional load, training which consists of strength training, various types of endurance and volleyball techniques.

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RELATIONSHIP OF AGILITY WITH TESTS OF SPECIFIC SPEED IN FOOTBALL

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SUMMARY

The research was conducted on a sample of 52 footballers of cadet with the main goal of the research to determine the importance and magnitude of the impact of manifestations of agility on the results in tests of the specific speed of running in young footballers. Seven variables for the agility estimation were applied in the research, which represented the predictor set of variables and 4 variables for the evaluation of the specific running speed as the criterion variable. Four regression analyses were used to determine the significance of predictive variables on criterion variable. The results of the regression analysis indicate that the system of predictive variables that was represented by the agility tests had achieved statistically significant influence on the results in the tests of the specific running speed with a high and significant coefficient of multiple correlation at the level of statistical significance p = .01 i p = .05.

Keywords: football, agility, situational motor skills, influence, regression analysis.

INTRODUCTION

Football is a sports game that belongs to polystructural sports, which is a dominant complex structure of cyclic and acyclic type, with the high degree of complexity. Football belongs to group of sports that are based on the movement of a complex nature, including movements of cyclic and acyclic types, in which the result depends on the cooperation of members of the team. Numerous and varied actions, complex, dynamic activities, that are carried out in variable situations, with or without ball, in conditions when opponents of the team, individually or in cooperation, prevent the build of an attack, or attempt to get possession of the ball are typical for football.

Starting from the situations in the game, it must be noted that the performance of actions in attack or defence, depends on the ability of the player to perform a certain movement of different intensity, in different directions and different parts of the field, which besides basic motor skills, also require specific motor skills related to football, among others, and dribbling the ball. Being agile in a motor sense means to be adroit. This ability means performing a maximum acceleration on a short distance (in two to three steps), but successfully stopping with a hop step or braking phase (one-step) or in two steps and the maximum acceleration in the other direction (Verstegen & Marcello, 2001). Agility is a fast change in the direction of movement. This is associated with the ability to accelerate the body, i.e. achieve the greatest acceleration, and with the ability to stop, i.e. achieving the highest possible deceleration. When repeating the change in the direction of movement, it is always necessary to achieve maximum acceleration and stopping of movement in the shortest distance possible (Milanović, 2013). Agility in the motor space has so far been considered in various manners. In this sense, agility can be seen as an isolated motor skill, but due to its complexity, and still insufficiently investigated structure, and cognitive demands, agility may be more optimally considered as an extremely complex motor skill. In sports games, agility is one of the leading abilities, which includes football, that is, in sports of complex technical and tactical action because of the existence of opponents whose goals are identical, but their directions of actions are not the same. In many sports, and this also applies to football, the ultimate success often depends on the timely and rapid movements of the body in space. According to the experts of sports games and football, agility is one of the most important motor skills when considering it from the aspect of its contribution to the achievement of top sports results (Bompa, 1999.; Graham, 2000). Some experts believe that football is a sport discipline of agility (Weineck, 2000), while other skills and characteristics, and various technical-tactical knowledge is evaluated with much lower value coefficients. Agility in a football game should be seen as a specific skill, which means that training focused on the development of agility must be filled with those contents that are important for a particular player, or for the position that the player is playing. The analysis of the influence of agility on the specific structures of football movements was done by the following researchers: Plisk (2000), Bajrić (2008), Grbović (2013), Gardašević, Bjelica and Popović (2015).

METHOD OF WORK

Sample of subjects

The sample of subjects was made of 52 subjects - cadets aged (14 - 16), who are continuously training football in football clubs: FK "Borac" Banja Luka, FK "BSK" Banja Luka and FK "Krupa" Krupa na Vrbasu. The basic criterion in selecting a sample of subjects was that regularity in training and performances in the championship and Cup matches for those clubs.

The sample of variables

A sample of variables for assessing agility that represented the predictor set of variables: Agility test 93639NN (MAG9NN), Hexagon test (six-way sideways hops, .MAGHEK), sideways shuffle test (MAGKUS), Agility test 93639OK (MAG9OK), 20 yards test. (MAG 20Y), Running 4 x 5 meters with changing direction under 90^0 i 180^0 (AG4X5M) and T – Agility test (MAG T).

The criterion in the research was four variables for assessing the specific speed of running each separately: Running speed at 30 m (SNSP30), Running speed in slalom (SNBTSL), Running speed per semicircle (SNBTPO) and Running speed with change of direction at right angle (SNBTPP).

METHOD OF DATA PROCESSING

Several regression analyses were applied in order to determine the effects of motoric variables – agility, labelled as an input or predictor system of variables on the effectiveness of realization of situational-motor test in football, which serve for assessment of performance in realization of situational-motor tasks of football players, marked as an output or criterion.

RESULTS AND DISCUSSION

Using the regression analysis, the significance and size of the influence of the prediction system of variables on each variables criterion was determined, as well as the possibility of predicting results in any of the criterion variables based on the individual influence of each of the variables of the predictor system.

In the research, agility manifestations were analysed as a set of variables - as a predictor in determining the significance and magnitude of the influence on the efficiency in the realization of the specific running speed tests in football as the criterion set, whereas each variable from the set of specific speed tests was being considered as a criterion.

Regression analysis of the criterion variable SNSP30 - running speed at 30 meters

Table 1 shows a regression analysis of the criterion variable SNSP30 that estimates the running speed at 30 meters. Table 1 shows the regression analysis of criterion variable SNSP30 - What is estimated running speed at 30 meters. By doing the analysis of the table presented it can be seen that there is a statistically significant correlation of the prediction system of the variables with the criterion, if the multiple correlation coefficient is .78, which represents a significant value at the level p = 0.000. The explained part of the common variance is 60 %. Out of the seven variables used to evaluate agility, one can notice that the largest statistically significant influence on the criterion variable SNSP30 – running speed at 30 meters has an agility estimation test with angular changes in direction of motion MAGT – T- agility test (Beta) .379 which is significant at the level .004 and a test for the evaluation of frontal agility MAGHEK – running in hexagon with six-way sideways hops (BETA)= .261, which is significant at the level p =.031. At the boundary of statistical significance is also an agility estimation test with the change of direction by rotation MAG9OK – agility test 93639OK (BETA) = .234 which is significant at the level .058.

Table 1. *The regression analysis of criterion variable SNSP30 – running speed at 30 meters*

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		
					R Square Change	F Change	df1
1	.776[a]	.602	.539	2.28922	.602	9.518	7

Model	Change Statistics	
	df2	Sig. F Change
1	44	.000

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	349.168	7	49.881	9.518	.000b
	Residual	230.582	44	5.241		
	Total	579.750	51			

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-12.453	10.230		-1.217	.230
	MAG9NN	.052	.088	.078	.584	.562
	MAGHEK	.094	.042	.261	2.233	.031
	MAGKUS	-.062	.067	-.103	-.924	.361
	MAG9OK	.144	.082	.234	1.744	.058
	MAG2OY	.009	.112	.009	.081	.936
	AG4X5M	.257	.170	.192	1.511	.138
	MAGT	.265	.086	.379	3.086	.004

Table 2. *The regression analysis of criterion variable SNBTSL – running speed in slalom*

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		
					R Square Change	F Change	df1
1	.826[a]	.683	.632	3.01064	.683	13.521	7

Model	Change Statistics	
	df2	Sig. F Change
1	44	.000

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	857.860	7	122.551	13.521	.000b
	Residual	398.814	44	9.064		
	Total	1256.673	51			

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-34.018	13.454		-2.528	.015
	MAG9NN	.134	.116	.138	1.154	.255
	MAGHEK	.114	.056	.214	2.054	.046
	MAGKUS	-.082	.088	-.094	-.941	.352
	MAG9OK	.322	.108	.357	2.973	.005
	MAG2OY	.493	.147	.333	3.342	.002
	AG4X5M	.284	.224	.144	1.269	.211
	MAGT	.102	.113	.099	.899	.373

The regression analysis of criterion variable SNBTSL – Running speed in slalom

Table 2 shows a regression analysis of the criterion variable SNBTSL, estimating the speed of slalom running. In the table shown, it can be seen that there is a statistically significant correlation between the prediction system of the variables with the criterion and that the coefficient of multiple correlations is .83, which represents a significant value at p = 0.000 level, and the explained part of the common variance is 68 %. Out of the tests applied to assess the agility, one can notice that largest statistically significant influence, on the criterion variable SNBTSL – running speed in slalom, is with tests for agility evaluation with the change of direction by turn MAG20Y –20 yards test with back running (Beta) .333 which is significant at the level .002, and variable MAG9OK – test agility test with the change of direction by turn (BETA) = .357 which is significant at the level .005 and variable for assessing frontal agility MAGHEK – running in hexagon with six-way sideways hops (BETA) = .214, which is significant at the level p =.046. Other variables did not show statistically significant influence on the successful realization of the SNBTSL test – running speed in slalom.

The regression analysis of criterion variable SNBTPO – running speed per semicircle

Table 3 shows a regression analysis of the criterion variable SNBTPO, estimating the running speed per semicircle. By insight in the given table it can be seen that there is a statistically significant link between the predictor system variable and the criterion, since the coefficient of multiple correlation is .73, which represents a significant value at the level p = 0.000, and the explained part of the common variance is 54 %. Out of seven applied agility tests, the largest statistically significant influence, on the criterion variable SNBTPO – running speed per semicircle, is with test for agility evaluation with the change of direction by turn MAG20Y –20 yards test with back running with the change of direction by turn (Beta) .267 which is significant at the level .032 and variable for assessing frontal agility MAGHEK – running in hexagon with six-way sideways hops (BETA) = .249, which is significant at level p =.054.

Other variables did not show statistically significant influence on the successful realization of the SNBTPO test – running speed per semicircle.

Table 3. *The regression analysis of criterion variable SNBTPO – running speed per semicircle*

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		
					R Square Change	F Change	df1
1	.733a	.537	.463	4.84371	.5 37	7.293	7

Model	Change Statistics	
	df2	Sig. F Change
1	44	.000

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	1197.752	7		7.293	.000b
	Residual	1032.305	44	171.107		
	Total	2230.058	51	23.461		

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.451	21.646		.113	.910
	MAG9NN	-.085	.187	-.065	-.452	.653
	MAGHEK	.177	.089	.249	1.977	.054
	MAGKUS	.182	.141	.155	1.289	.204
	MAG9OK	.120	.174	.099	.686	.496
	MAG2OY	.525	.237	.267	2.213	.032
	AG4X5M	.532	.360	.203	1.478	.147
	MAGT	.220	.182	.160	1.209	.233

The regression analysis of criterion variable SNBTPP – running speed with the change of direction under right angle

The results of regression analysis of criterion variable SNBTPP, which estimates running speed with the change of direction under right angle, are shown in Table 4. U In the table it can be seen that there is a statistically significant link between the system of predictor variables and the criterion, if the multiple correlation coefficient is .80, which is a significant value at level p = 0.000. The explained part of the common variance is 63 %. The applied agility assessment tests show that the largest statistically significant influence, on the criterion variable SNBTPP – running speed with the change of direction under right angle, is with agility test AG4X5M – running 4x5 meters with the change of direction under 90 and 180 degrees, which estimates agility with angular changes in direction of movement, (BETA) .436 which is significant at level .001 and variable for assessing frontal agility MAGHEK – running in hexagon with six-way sideways hops (BETA) = .279, which is significant at level p =.017.

Table 4. *The regression analysis of criterion variable SNBTPP – with the change of direction under right angle*

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.796ᵃ	.634	.576	3.52711	.634	10.894	7	44	.000

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	948.677	7	135.525	10.894	.000b
	Residual	547.381	44	12.440		
	Total	1496.058	51			

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-34.029	15.762		-2.159	.036
	MAG9NN	.058	.136	.055	.428	.671
	MAGHEK	.162	.065	.279	2.488	.017
	MAGKUS	.000	.103	.000	.003	.998
	MAG9OK	.178	.127	.181	1.401	.168
	MAG2OY	.227	.173	.141	1.313	.196
	AG4X5M	.936	.262	.436	3.569	.001
	MAGT	.000	.132	.000	.003	.998

Based on the results it can be concluded that they are similar to the previous research in football (Bajric, O., Mekic and Bajric, S., 2010; Bangsboo, Mohr and Krustrup, 2006; Basinac, Bajric, O. and Bajric, S., 2016).

CONCLUSION

The main goal of the research was to determine the importance and magnitude of the impact of chosen manifestations of agility on the results in tests for estimation of the specific speed of running on sample of 52 young footballers, ages between 14 and 16. Based on the results of the regression analysis it can be concluded that the system of predictor variables that was represented by the agility estimation tests had a statistically significant influence on each test of specific running speeds with high and significant multiple correlation coefficient. Generally, a positive influence of agility on each individual variable for assessment of specific running speed can be ascertained. The following variables had a particular influence on the performance of tests to evaluate specific running speeds with statistical significance: six-way sideways hops (MAGHEK), the 20 yard agility run (MAG20Y), frontal agility with turns (MAG9OK) and running 4 x 5 meters with change of direction under 90 and 180 degrees (AG4X5M). In order to explain the statistically significant influence of the agility manifestations on the tests of the specific running speed, the fact of similarity of the movement structure and the high intensity of their performance should also be taken into account with the agility assessment tests and with the tests of the specific running speed estimates belonging to the same load intensity zone. The obtained results may be of use to football coaches and all those who in any way, also take part in the work with the football players in order to improve the planning and programming of training process based on scientific facts.

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EFFECT OF TARGET SIZE ON SPEED-ACCURACY TRADEOFF OF INSTEP KICK

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SUMMARY

The speed-accuracy tradeoff of fast movements acts inversely and as such known as the *Fitts's law*. The aim of this study is to determine how target size affects the instep kicking speed and accuracy. The study involved 33 male subjects, average age 15±0.9 years. The subjects executed kicks under different instructions (instruction to increase kicking accuracy or speed) into targets with different sizes (small target: 50×50 cm and large target: 150×150 cm). For kicking performances assessment we monitored: the mean radial error - measure of absolute precision, bivariate variable error - measure of kicking consistency and ball speed - measure of kicking speed. The results indicate that the target size had an effect on the hitting consistency ($p=0.037$), as well as the potential trend of effect on the absolute precision ($p=0.068$) and the ball speed ($p=0.077$). It can be concluded that the increase of target size affects the increase in speed but also resulting in reduction of accuracy.

Keywords: *Fitts's law*, motor control, bivariate variable error, medium radial error,

INTRODUCTION

One of the most used kicks in football is the instep kick, i.e. kick of the ball with the front part of the foot, therefore its improvement is seen as an important segment of football technique. The speed and accuracy of the instep kick are the two dominant factors on the basis of which the success of execution of this technical element is determined. If the execution of the instep kick on the goal is considered, fast kick execution is important because the speed of the ball surprises the opponent, i.e. the goalkeeper, reducing his ability to react, while on the other hand, kick executed with high accuracy pushes the ball away from the opponent, preventing him from catching it.

The speed-accuracy tradeoff is theoretically described, according to which there is an inverse relation between these two variables, shown as a ratio of functions of speed and accuracy (Fitts & Peterson, 1964). Fitts summarised this ratio in an empirical model, which is called the *Fitts's law*, wherein also described that the aimed target size is reversely proportional to the movement duration i.e. directly proportional to movement speed. Thus, giving instructions to carry out the movement more accurately reduces speed, and vice versa.

The majority of results describing the ratio of speed and accuracy were obtained in studies involving simple single-joint movements (Fitts & Peterson, 1964). However, results obtained in the execution of fast, ballistic and discrete movements, such as throwing and shooting, show certain deviations from the theoretical approach. In particular, Van den Tillaar & Ettema (2003) have shown that when executing throwing tasks with accuracy as the dominant instruction in carrying out a motor task, the speed of execution decreases, with no improvement to accuracy, which goes against *Fitts's law* models. A detailed relation of mutual dependance between speed and accuracy of the executed instep kick is given in the Van den Tillaar and Ulvik's research (2014). The obtained results in this study have shown that the instruction focused on accuracy affected the reduction of foot speed, but also, the same instruction resulted in increase of kicking accuracy.

The aim of this study was to investigate the effects of various target sizes on kicking speed and kicking accuracy. Considering earlier research on which *Fitts's law* is based, a hypothesis has been established that the reduction in target size negatively affects the executed kicking speed; while on the other hand, it positively influences the accuracy of the instep kick.

METHODS

The experiment determined the possible effect of the *target size* on the dependent variables of speed and accuracy of the kick. In this manner, instructions demanded the execution of a kick to the center of the target, from a distance of 9 meters from the target, represented by a 50×50 cm or 150×150 cm square, wherein kicks were executed with the primary focus on speed or accuracy, depending on the instructions.

Subjects

The study involved 33 male subjects, average age of 15 years (± 0.9), average height of 168.5 cm (± 7.2), and average weight of 55.5 kg (± 5.5). The subjects were players who have spent at least 3 years in an organized football training process.

Procedure

The motor tasks variables refer to the change of conditions for the execution of the instep kick. Within the independent variables, the *instructions* factor and the *target size* factor are distinguished by their different modalities. Modalties of motor task execution within the *instructions* factor are to execute a primarily: (1) *precise* kick (**P**) into the center of the target with a secondary focus on kick speed ; (2) *fast* kick (**F**) with a secondary focus on kick precision; The modalities of carrying out motor tasks within the *target size* factor are: (1) target with dimensions of 50×50 cm (small target size **- 50**); (2) target with dimensions of 150x150 cm (large target size **- 150**).

In order to investigate the effects of the *target size* and *instrucions* factors on the accuracy and speed variables, the following dependent variables were defined (Hancock et al., 1995): *mean radial error* (*MRE*) used for assesment of absolute precision (expressed in centimeters), *bivariate variable error* (*BVE*) used for assesment of consistency (expressed in centimeters) and *kicking ball speed* (*V*) used for assemsent of kicking speed, expressed in kilometers per hour (km/h).

$$\mathrm{MRE}=\overline{\mathrm{RG}}=(1/n)\sum_{i=1}^{m}(\mathrm{RG_i}),$$

$$\mathrm{RG}=(x^2+y^2)^{\frac{1}{2}}$$

$$\mathrm{BVE}=\{(1/n)\sum_{i=1}^{n}[(x_i-x_c)^2+(y_i-y_c)^2]\}^{\frac{1}{2}}$$

For each of these formulas, *n* represents the number of executed kicks, *x* and *y* values represent the distance of the center of the hit from the vertical or horizontal axis, and *RE* represents the radial error of the subject.

The subjects were given specific instructions for execution of each motor task. Subjects were given instructions for fast and precise kicks, i.e. the following two instructions: (a) execute a primarily precise kick to the center of the target with a secondary focus on kick speed; and (b) Execute a primarily fast kick with a secondary focus on kick precision. Both of these instructions were implemented when the target size was visually changed: (a) target with smaller dimensions (50×50 cm) and (b) target with larger dimensions (150×150 cm). The subjects switched to a motor task opposite to the previous one, on the principle of randomization, after each series of kicks. In order to obtain results with a high level of reliability, the subjects executed 15 kicks to the goal for each task, arranged into three series.

All kicks were carried out from a distance of 9 meters from the target. The approach angle to the ball was defined within the range of 30º to 60º in relation to the direction determined by the position of the ball and the target (Figure 1). The length of subjects' approach was not determined; instead the subjects estimated the optimal length of approach appropriate for execution of these motor tasks during the process of familiarization with the test.

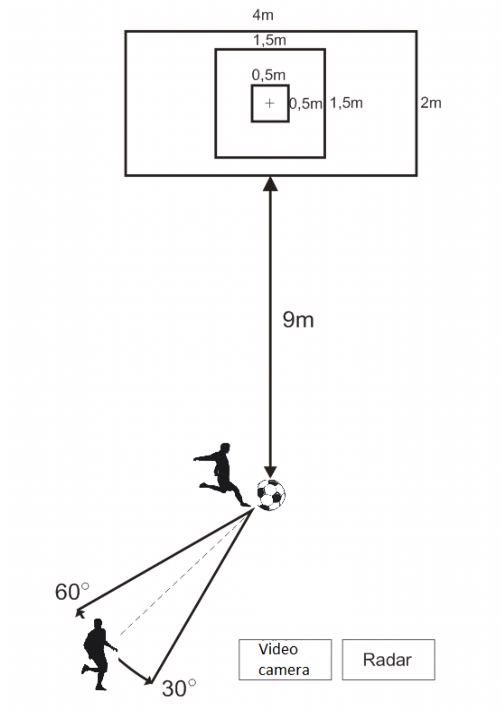

Figure 1. Illustration of motor task execution

The speed of the ball was measured by manual radar for speed estimation (Sports Radar Speed Gun SR 3600, Homosassa, FL, USA). The experiment used square-shaped targets measuring 50×50 cm and 150×150 cm, made of sponge 5 mm thick and 5 cm wide, placed on a frame made of a wooden board, sponge and memory foam, attached to the wall. Each kick was captured by a high-resolution camera (*Canon EOS*, Japan). In order to make it easier and more precise to determine the position and size of the ball imprint during its contact with the wall, a multiplatform application was developed in Java programming language. The purpose of the application is to determine the coordinates of the contact center in the coordinate system defined by reference points on the wall (the points must be visible on the image), in the series of images made at the moment of contact of the ball with the wall.

Statistical analysis

Representative measures of mean values and standard deviations were used from the descriptive statistics. For the research of effect of the *instruction* factor and the *target size* factor on monitored dependent variables of accuracy and speed of the kick, the results were analyzed through a two-way ANOVA with repeted measures (factors: *instruction* and *target size*) with all appropriate post hoc procedures. Values $p<0.05$ were selected for determining the level of statistical significance.

RESULTS

Figure 2 shows the average values with standard deviations for variables *V*, *MRE* and *BVE* for different modalities of the *instructions* (fast and precise kick) and the *target size* (50 and 150).

Two-way ANOVA with repeated measurement has shown that there is a significant effect of *instructions* on *V* as can be seen in Table 1. As expected, post hoc analysis has determined that significantly higher speed have been achieved in instructions for fast execution in comparison to instructions for precise execution ($p=0.000$). Also, ANOVA has shown that there is a certain trend that the *target size* factor has an effect on *V*. A change trend in the direction of lower kick speed ($p = 0.077$) is achieved when carrying out a kick to a target of smaller size.

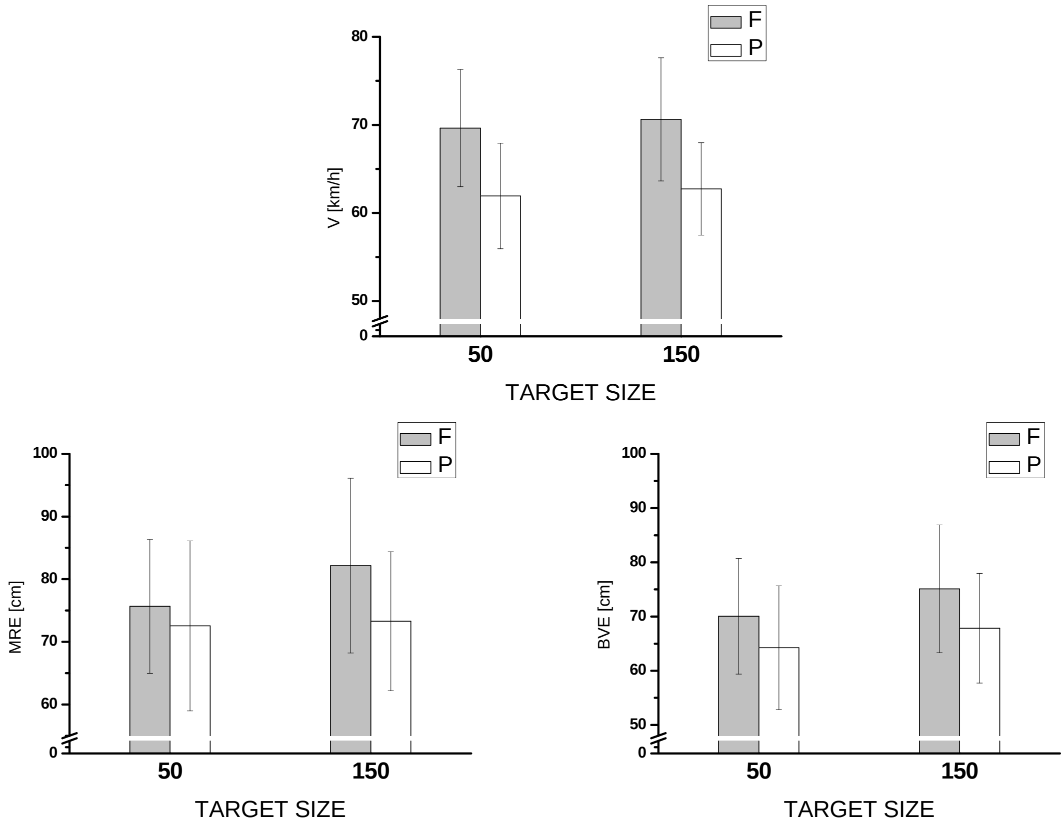

Figure 2. Average values with standard deviations for variables *V*, *MRE* and *BVE* in execution of instep kicks with different *instructions* (fast kick - F and precise kick - P) in different target sizes (50 and 150 cm).

ANOVA with repeated measurement has shown that there is a certain trend that the *target size* factor has an effect on the *MRE* (Table 1). It was observed that subjects, when kicking the ball towards targets of smaller size, expressed lower *MRE* values, i.e. they achieved a better precision of hits (p=0.068). Also, ANOVA with repeated measurements has shown that there is a statistically significant effect of the *instructions* factor on the *MRE* variable. Post hoc analysis has shown that significantly higher precision, measured by *MRE*, was achieved with the precision instructions compared to *MRE* results obtained by speed instructions (p=0.007).

Since ANOVA with repeated measurement has shown that there is a significant effect of the *target size* factor on the variable *BVE*, post hoc analysis has found that a significantly lower value of *BVE*, i.e. greater consistency of kicks, was achieved with smaller size targets compared to kicks to larger targets (p=0.035). Also, ANOVA with repeated measurement has confirmed that there is a statistically significant effect of the *instructions* factor on the *BVE* variable (Table 1). Post hoc analysis has found that giving instructions to a subject to execute a kick with a primary focus on precision has affected the *BVE* value reduction, i.e. affected the increased consistency of kicks, compared to kicks where the primary focus was on swift execution (p=0.001).

Table 1. Overview of results of two-way ANOVA for main factors *instructions* and *target size*, as well as their interactions (target×instruction) with monitored variables

		TARGET	INSTRUCTION		TARGET × INSTRUSTION	
V	$F_{(1,25)}$	3.403	$F_{(1,25)}$	128.791	$F_{(1,25)}$	0.037
	p	0.077	p	0.000	p	0.850
	$\eta p2$	0.120	$\eta p2$	0.837	$\eta p2$	0.001
	$1\text{-}\beta$	0.426	$1\text{-}\beta$	1.000	$1\text{-}\beta$	0.054
MRE	$F_{(1,25)}$	3.646	$F_{(1,25)}$	8.468	$F_{(1,25)}$	2.023
	p	0.068	p	0.007	p	0.167
	$\eta p2$	0.127	$\eta p2$	0.253	$\eta p2$	0.075
	$1\text{-}\beta$	0.451	$1\text{-}\beta$	0.799	$1\text{-}\beta$	0.277
BVE	$F_{(1,25)}$	5.000	$F_{(1,25)}$	14.630	$F_{(1,25)}$	0.158
	p	0.035	p	0.001	p	0.694
	$\eta p2$	0.167	$\eta p2$	0.369	$\eta p2$	0.006
	$1\text{-}\beta$	0.575	$1\text{-}\beta$	0.957	$1\text{-}\beta$	0.067

DISCUSSION

The most important results of this experiment indicate that the *target size* factor had an effect on the variable used for assesment of the consistency of hits (*BVE*) (p=0.037), as well as a potential effect on the measure of absolute precision (*MRE*) (p=0.068) and the kicking speed (*V*) (p=0.077).

With regard to the speed of execution, the achieved average speeds of 69.63 km/h and 61.92 km/h for a smaller target (50×50 cm), and a slightly higher kick speed of 70.63 km/h and 62.71 km/h for a larger target (150×150 cm) (depending on whether the given instruction focused on speed or accuracy, respectively), have shown certain differences in average speeds in execution of kicks into targets of different sizes. In support of the *Fitts's* law, according to which the duration of the movement is increased with the accuracy which is reversely proportional to the target size, the obtained result indicating that a higher ball speed is achieved when kicking a ball into a larger target is expected. Also, the ratio of movement length and target size, which changes the duration of the movement, or the speed of the execution of the motor task, explains the effect of the *target size* on kicking speed (Crossman & Goodeve, 1983). The time required to carry out the movement is in function of the task difficulty index, explained by the logarithm of the quotient of the movement length and target width. This logarithmic function can clearly describe the relation of expressing the speed and accuracy of an executed motion by which the duration of the movement increases (i.e. the speed of motion decreases) when the task is to hit smaller targets (Jagacinski et al., 1980). So, as the duration of the movement increases linearly with the difficulty index defined with target width, lower speeds are expected when hitting smaller targets. In the context of this result, it can be assumed that the visual effect when hitting larger targets has enabled a greater degree of freedom of movement execution by reducing the accuracy requirements and thereby increasing the speed of the kick.

As mentioned in the previous paragraph, the obtained results indicate that the *target size* has a significant effect on the *BVE* as a measure of kicking consistency. In addition to the effect of the *target size* on kicking consistency, a certain trend of statistical significance of the effect of *target size* on the measure of kicking precision, monitored by the *MRE*, was also observed (p=0.068). The trend of the *MRE* value is reflected in reduced errors when shooting into smaller targets, i.e. increasing precision, compared to larger targets. It is important to note that the precision of specific task can be described through a measure of absolute precision (average deviation of hits from the center of the target – *MRE*), but to describe the precision as a motor capability more accurately, *BVE* has been introduced, through which the level of kicking consistency is assessed. In a specific manner, this measure describes the motor capability of accuracy of the executed motor task and enables analitical overview of the quality of the executed motor task, in the context of subjects' consistency of hits, regardless of whether those hits are close or far from the center of the target. The obtained results indicate that *BVE* is higher in shooting a larger target i.e. that shooting a smaller target achieved more consistent results. When shooting a target measuring 50×50cm, the results for

BVE were 70cm and 64cm, opposite to 75cm and 67cm for a target measuring 150×150cm, depending on whether the given instruction focused on speed or accuracy, respectively. As can be seen, a smaller target has affected better grouping of kicking hits, or better consistency. In this regard, it is necessary to note that the expression of a certain level of accuracy of an executed motor task is significantly influenced by the speed of its execution (Tillaar & Ulvik, 2014) Therefore, it can be said that the speed of execution indirectly affects the consistency. This conclusion is supported by the obtained results of the speed based on which it can be concluded that lower speeds of execution are achieved by hitting smaller targets. Therefore, the lower speed of execution is capable of optimizing the movement and more consistent execution in a technical sense. In this case, the index of task difficulty has been determined by the size of the target so it was to be expected that easier tasks, i.e. hitting a larger target, results in more precise and consistent results. However, hitting targets of larger size involves increased speed of movement, and as a result, poorer accuraccy are achieved. The obtained results are compatible with the results of previous research carried out on simple motor tasks, based on which the researchers concluded that the increase in target size reduces accuracy requirements, which results in a higher speed of movement leading to reduced precision and increase in variability (Bootsma et al., 1994). All of this explains the results obtained, as well as the mechanism which results in higher consistency in more difficult tasks. According to obtained results, it can be assumed that in training the technique of instep kick it is necessary to use smaller targets if the aim of the training program is to improve the consistency of kicking.

CONCLUSION

When analyzing the obtained results with variables of kicking precision, consistency and speed, it can be concluded that they fully follow speed-accuracy tradeoff defined by the *Fitts's law*, according to which an increase in target size affects the speed of the execution, resulting an increase in errors.

The results obtained from the experiment have practical application in the competitive and training processes, and as such they confirm and supplement the findings so far in the context of more significant factors that influence the execution of the instep kick. In order to further examine the effect of the *target size* factor on the speed and accuracy variables of the instep kick, it would be neccessary to carry out a kinetic and kinematic analysis of the movement of the leg during execution of the kick. Depending on specific executed tasks determined by the target size and the type of instruction, the kinematic and kinetic variables of motion would be obtained, which could further explain the law of the ratio of speed and accuracy of the kick, wherein the coordination schemes of the kick execution could be shown in a clear manner, depending on these factors.

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EFFECTS OF DIFFERENT TRAINING PROGRAMS ON AGILITY PERFORMANCE IN BASKETBALL PLAYERS

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SUMMARY

Basketball is one of the most popular sports in which a large number of complex, variable and unpredictable movements and situations require fast and adequate motoric responses. The aim of this study was to analyse, compare and to synthesize obtained data from a large number of studies conducted by national and international authors in the area of motor agility among young basketball players. The aim also was to show a clear picture about the possible variables that can enhance agility using different longitudinal training methods. Searching was limited to papers published in the period from 2007 to 2018. Literature was collected by searching the Internet and the following databases: Kobson,Google Scholar, Medline and PubMeb. This review paper contains 32 studies, selected according to the established criteria and provides a detailed examination and discussion of the papers which have dealt with this problem. The data of all the studies clearly show that the plyometric training is a very popular and very effective form of physical conditioning in athletes This method significantly improved the change of direction performance. Besides, the balance training, the rope jump training, SAQ training as well as the combined plyometric training with other popular training modalities have also been efficient compared to vibration training which has been less efficient. The effects of training methods could vary because of a large number of variables, such us program duration, training volume, rest interval or intensity and subject characteristics (gender, age). These data should be taken into account by strength and conditioning professionals to design an optimum plyometric program to enhance change of direction ability in athletes. This review paper has identified a common conclusion from all of the selected papers and the reason for the variations, in case of their existence.

Keywords: Basketball players, training process, agility, effects

INTRODUCTION

Basketball is one of the most popular sports played and watched all around the world that belongs to the group of polystructural sports consisted of both simple and complex movements, and performed by members of the teams in conditions of cooperation and countering opponent during the game (Živković, 2012). Basketball is a sport that consists of short but very intense activities, interrupted by longer or shorter periods of passive or active rest, during which the basketball player recovers. This team sport involves complex motor activity in which a large number of complex, variable and unpredictable movements and situations require fast and adequate motoric responses. In basketball the basic techniques of kicking, passing, dribbling dominate, including the player's position as well as the structure of the attack and defense (Shaji & Isha, 2009). The success of the basketball player greatly depends on his stamina that is developed by using an adequate training content, primarily in the context of fitness training. Explosivity, speed and agility are motor abilities that are crucial for the success in basketball game. Given the many situations in a basketball game which are dominated by the sudden movement direction changes such as forward, backward, lateral, special attention should be given exactly to the development of agility.

Agility is a vital component for the success in basketball players (Asadi, 2013). It is is one of the most important components of the fitness preparation of the basketball players, which directly influences the final performance of the game. Agility (Greek. agilis - agile, diligent, fast, brisk) is the ability to quickly and effectively move the body through space in the conditions of sudden stopping and movement direction change. At present, there is no consensus among the sports science community for a clear definition of agility. Agility has classically been defined as the ability to change direction rapidly (Bloomfield, Ackland, & Elliot, 1994; Mathews, 1973), Agility is also defined as: 1) the ability to accelerate, slow down and rapidly change the direction of movement, keeping control of the movement and without losing speed (Brittenham, 1996); 2) the ability to start (or accelerate), stop (or decelerate and stabilize) and change direction quickly,while maintaining proper posture (Pearsons & Jones, 1998); 3) the ability to change the direction of movement without losing balance, speed, strength, and movement control (Pearson, 2001); Essentially, agility is a movement characterized by changes in speed (acceleration, deceleration), direction and movement direction. It represents a complex motoric characteristic in which other motor abilities, primarily strength, speed, balance and coordination have a certain role to play.

At the very top of the hierarchical pyramid of motor abilities in basketball are the explosive speed properties, among which also agility. Agility depends on the set of properties that influence the performance of the complex movements with maximum intensity, and the complexity of the movement (the degree of the change in direction) determines the characteristics of the interactions of particular motor properties. Complementarity of the influences of the various motor abilities is not controversial, however, in theory and in practice, it is not known to what extent certain motor abilities contribute to the different conditions of agility manifestation. The connection between the agility and balance can be explained by the demand on the athletes to regulate the transmission of the brunt of the body while undergoing various changes of the body position. The manifestation of the agility depends on numerous factors: reaction and recognition of situations, starting position, initial acceleration, the importance of the initial step in motion, acceleration, high speed body control, reaching and overtaking the opponent, leg work, direction changes, false and evasive actions, spatial reaction and stopping.

The programming of the basketball training presupposes the knowledge of the relationship between the sporting activity and the psychosomatic dimensions of basketball players that influence the performance, so that all the necessary operations in certain stages of training and competing can be determined on the basis of this data.

Training of young basketball players is a long - standing systematic process, in the course of which attention should be paid so that the load increase and the total energy – conditioning, technical, tactical and mental requirements are applied gradually during the growth and development phases. The basics of childhood training should be set up through a versatile development, and not only through the narrow basketball training, as this will create a better foundation for later superior performance (Bompa, 2005). The diversity of training loads, the evaluation of individual differences between players and appropriate planning of phase to phase progression, will result in a more efficient training program and will not lead to early specialization, which is the most common side effect of the inadequate load progression. Plyometric training is ranked among the most frequently used methods for the development of the motor abilies in team games, such as basketball (Lehnert, Hůlka,Malý,Fohler & Zahálka, 2013).

A large number of studies (Shaji & Isha, 2009; Chaudhary & Jhajharia, 2010; Shallaby, 2010; Bal, Kaur, Singh & Bal, 2011; Asadi & Arazi, 2012; Arazi, Coetzee & Asadi, 2012; Živković, 2012; Nandalal, 2013; Asadi, 2013; Dadwal, 2013; Mitra, Bandyopadhyay & Gayen, 2013; Ramachandran & Pradhan, 2014; Poomsalood & Pakulanon, 2015; Aalizadeh et al, 2015, McCormick at al., 2015; Ichrak, Yassine, Roy & Souhaie, 2018) confirmed the effectiveness of plyometric training program on agility performance in basketball players. Plyometric training is generally used to increase strength end explosiveness but it also can enhance agility of athletes. That is why this method is the most widely used in basketball.

The aim of this study was to analyse, compare and to synthesize obtained data from a large number of studies by national and international authors in the area of motor agility among young basketball players in the last 10 years. Data from all the collected studies were critically appraised and analyzed.

For the realisation of the defined aim of the research, the following tasks were realised: the key words for searching scientific research have been defined; an overview of databases which allow easy navigation through the available research was condacted; the selection of collected research on the bases of defined criterion was condacted; on the bases of analysis and synthesis of collected research, the general conclusion was defined.

METHODS

Literature searching

Literature was collected by searching the Internet and the following databases: Kobson, Google Scholar, Medline and PubMeb. The additional literature in the form of textbooks, was also used. Searching was limited to papers published in the period from 2007 to 2018.

The literature search was conducted using the following key words: basketball, training process, agility, effects. The selection was done on the bases of certain criteria. All of the considered papers examined different training programs and agility, i.e. their connection regarding the different effects of different training programs on motor agility. Besides, the second important condition for acceptance of the papers was that they had to examine motor agility in young basketball players. Titles and abstracts of identified articles were checked for relevance in the first stage of screening. In the second stage, full-text articles were retrieved and considered for inclusion. References from all the collected papers were examined in order to get more studies that were in the field of this problem. The exclusion criteria were as follows: inadequate titles, duplicated research and inadequate sport.

Theoretical consideration of the problem

For consideration of the collected research, both descriptive and the method of theoretical analysis were used. The study included 32 closely related research studies that were carefully analyzed and met all the criteria for selection. The initial literature search identified 126 references (121 through database searching and 5 through other sources) which fulfilled some of the criteria of the study. However, a certain number were eliminated on the basis of different criteria (Figure 1), such as inadequate sport, duplicates and eligibility.

The collected and analyzed studies are shown in Tables 1. Each study is shown with the following parameters: authors of the paper and the year of its publishing, results of the research, method of research (participants, measuring instruments, study design and period of the research. The sample of participants was described by the following data: number of participants and groups, age and gender of participants. Measuring instruments were tests for agility assessment.

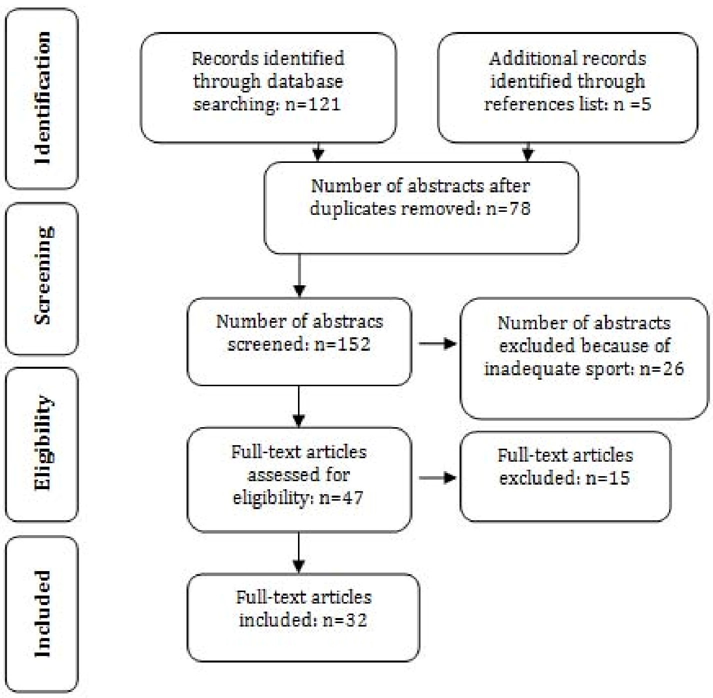

Figure 1. Summary of literature search

RESULTS

In this review paper, 32 studies that met all the criteria for selection and dealt with the motor agility in young basketball players were analysed. The initial literature search identified 126 references (121 through database searching and 5 through other sources) which fulfilled some of the criteria of the study. 94 studies were eliminated on the basis of different criteria (Figure 1).

Table 1. Studies analyzing the agility in young basketball players

Authors, year	Results of the research	THE METHOD OF RESEARCH					
		Participants			Measuring instruments	Study design	Period of the research
		Number of participants and groups	Age	Gender			
Ivković (2007)	Statistically significant effects of basketball training in Ex group.	N = 60 2 groups: Ex (n=30) Con (n=30)	13-14	Female	Side steps test	Ex – basketball physical and tactical preparation + PE classess (3 times a week for 60 min) Con – PE classess (3 times a week for 60 min)	12 month
Shaji & Isha (2009)	Statistically significant effects of combined training in Ex3 group.	N = 45 3 groups: Ex1 (n=15) Ex2 (n=15) Ex3 (n=15)	18-25	Male	T - test	Program (twice a week): Ex1 – plyometric Ex2 - dynamic stretching Ex 3- combined plyometric and dynamic stretching	4 weeks
Chaudhary &Jhajharia (2010)	Statistically significant effects of basketball training in Ex group.	N = 40 2 groups: Ex (n=20) Con (n=20)	18-25	Female	Shuttle run	Program (five times a week): Ex - plyometric training Con–standard basketball program	10 weeks
Shallaby (2010)	Statistically significant effects of plyometric training in Ex group.	N = 20 2 groups: Ex (n=10) Con (n=10)	≤ 16	Male	Shuttle run	Program (3 times a week for 120 min): Ex- the plyometric training Con – standard basketball program	12 weeks
Bal,Kaur &Singh (2011)	Statistically significant effects of plyometric training in Ex group.	N =30 2 groups: Ex (n=15) Con (n=15)	18-24	Male	T-test Illinois test	Program (3 times a week for 25 min): Ex: the plyometric training, 25 min a day + intercollege basketball competitions Con: participated in intercollege basketball competitions	6 weeks
Boccolini, Costa & Alberti (2012)	Statistically significant effects of rope jump training in Ex group.	N =28 2 groups: Ex (n = 14) Con (n = 14)	14	Male	LADT–Lane agility drill test	Program (3 times a week for 20 min): Ex - rope jump training (RJT) – jump forwards + a tehnical training program (RJT) Con – a tehnical training program	4 weeks
Asadi & Arazi (2012)	Statistically significant effects of plyometric training in Ex group.	N = 16 2 groups: Ex (n = 8) Con (n =8)	19-20	Male	Shuttle run T-test Illinois test	Program (twice a week for 55 min): Ex - high-intensity plyometric training program Con – a tehnical training program	6- weeks
Andrejić (2012)	Statistically significant effects of plyometric training in Ex 1 group.	N =21 2 groups: Ex1 (n=11) Ex2 (n = 10	12.5 ± 0.5	Male	Shuttle run	Program (twice a week for 90 min): Ex_1 – strength training (free full court basketball). Ex_2 - the combined plyometric and strength training	6 weeks

Arazi, Coetzee & Asadi (2012)	Statistically significant effects of plyometric training in both Ex 1 and Ex2 groups. Aquatic plyometric was more effective.	N= 18 2 groups: Ex1 (n=9) Ex2 (n=9)	18,81 ±1,46	Male	T-test, Illinois test	Program (3 times a week for 40 min): Ex_1 - aquatic plyometric training (AP) Ex_2 - land plyometric training (LP)	8 weeks
Živković (2012)	Statistically significant effects of proprioceptive training in Ex group.	N = 23 2 groups: Ex – (n=13) Con (n=10)	14-16	Male	Shutlle run Side-step test	Program (3 times a week): Ex-proprioceptive training 3 times a week Con – standard basketball program	6 weeks
Orhan (2013)	There was not statistically significant effects neither in Ex nor Con group.	N=40 2 groups: Ex (n=20) Con (n=20)	16-19	Both gender	Hexagon Test	Program (3 times a week): Ex - weighted rope jumping training Con (K; n=20) - technical training	8weeks
Nandalal, S. (2013)	Statistically significant effects of both Ex1 and Ex2 groups.	N =45 3 groups: Ex1 (n=15) Ex2 (n=15) Con (n=15)	16-18	Female	Shuttle run test	Program (3 times a week): Ex1 –the plyometric training Ex2 - strength trainig Con - standard program	8 weeks
Lehnert, Hůlka, Malý, Fohler & Zahálka (2013)	Statistically significant effects of plyometric training were observed only for Hexagonal Obstacle test.	N = 12 1 group	24,36± 3,9	Male	The "T" Drill test Hexagon test	Plyometric training (PT) program during the pre-season:twice a week during first month +4 times a week during next 2 weeks.	6 weeks
Asadi (2013)	Statistically significant effects of plyometric training in Ex group.	N = 20 2 groups: Ex (n=10) Con (n=10)	20.1±1 .3	Male	Shuttle run T-test Illinois test	Program (twice a week for 40- 50 min): Ex - plyometric training Con- - standard program	6weeks
Dadwal, 2013	Statistically significant effects of plyometric training in Ex group.	N = 40 2 groups: Ex (n=20) Con (n=20)	18-25	Female	Shuttle run	Program (3 times a week for 40-50 min): Ex - plyometric training Con - standard program	10 weeks
Mitra, Bandyopadhyay & Gayen (2013)	Statistically significant effects of plyometric training in Ex1 group.	N = 60 3 groups: Ex1 (n=20) Ex2 (n=20) Con (n=20)	18-23	Male	Illinois test	Program (3 times a week for 40-45 min): Ex1 - plyometric training group (PT) Ex2 - resistance training group (RT) Con - standard program	8 weeks
Parimalam & Pushparajan (2014)	Statistically significant effects of both experimental programs in Ex1 and Ex2 groups.	N = 60 3 groups: Ex1 (n=20) Ex2 (n=20) Con (n=20)	18-25	Female	Shuttle Run	Ex1 - basketball specific training programme, Ex2 - traditional method of conditioning and training programme Con - did not practice any specific training.	12 weeks
Gottlieb, Eliakim, Shalom, Dello-Iacono & Meckel (2014)	Neither training program had a significant effect on the Shuttle Run.	N = 19 2 groups: Ex1 (n=9) Ex2 (n=10)	16,3±0 ,5	Male	Shuttle Run	Programs: regular basketball training 3 times a week + experimental program (twice a week for 90 min): Ex1- plyometric jump training Ex2 - specific sprint training	8 weeks

Zarić (2014)	Statistically significant effects of combined training	N = 13 1 group: Ex	17-18	10	T-test	Program (12 micro-cycles, 53 individual training sessions and 8 pre-season matches): strength workouts, aerobic endurance, glycolytic speed endurance workouts, 26 basketball tactical-technical workouts	6 weeks
Ramachandran & Pradhan (2014)	Statistically significant effects of plyometrics training combined with dynamic stretching	N = 30 1 group	20.4 ±1.73	Both gender	Shuttle Run	Program (3 times a week): plyometrics training + dynamic stretching exercises	2 weeks
Ramateerth &Kannur (2014)	Statistically significant effects of combined plyometric and strength training program in Ex2 group.	N = 21 2 groups: Ex1 (n=10) Ex2 (n=11)	12-13	Male	Shuttle Run	Program (twice a week for 90 min): Ex1- a strength training group Ex2- a combined plyometric and strength training group	6 weeks
Badrić, Prskalo i Sporiš, 2015	There was not statistically significant effects	N = 10 1 group	13-14	10	Side-step test	Program (3 times a week for 45 min) within the school sports society: (the basic elements of basketball techniques) along with regular PE (2 x 45 min.	8 weeks
Saraswat, Malhotra & Sivaram, (2015)	Statistically significant effects of dynamic balance training	N = 30 2 groups: Ex1 (n=15) Ex2 (n=15)	15-20	Both gender	T- test	Program (3 times a week): Ex1-dynamic balance training 3 sessions. Ex1- conventional exercises	4 weeks
Poomsalood & Pakulanon (2015)	Statistically significant effects of plyometric training	N = 10 2 groups: Ex1 (n=5) Con (n=5)	18 - 23	Male	T-test	Program (twice a week): Ex1- plyometric training Con - standard program	4 weeks
Atanasković,Georgiev & Mutavdzić, 2015	Whole body vibration training didn't leads to significant changes in agility tests	N = 30 2 groups: Ex (n=15) Con (n=15)	14.56 ± 0.5	Male	T-test Zig-Zag test L-test	Program (twice a week): Ex - beside regular basketball training attended the whole body vibration training Con– attending only basketball training	6 weeks
Abraham, 2015	In all three experimental groups there were not a significant improvement of agility.	N=80 4 groups: Ex1 (n=20) Ex2 (n=20) Ex3 (n=20) Con (n=20)	13-18	Male	T-test	Program (3 times a week): Ex1 - plyometric training (PT) Ex2 - cirkuit (RT) Ex3 - cirkuit breaker program (RT) Con - standard program	12 weeks
Kamani & Nikseresht (2015)	Statistically significant effects of plyometric training. Detraining leads to reduce some of adaptations.	N=20 1 group	16 - 20	Both gender	Shuttle Run	Program (3 times a week for 90 min): Plyometric exercises agility measurement - before and after experimental period and after 3 weeks of detraining.	6 weeks
Diswar, Choudhary & Mitra, (2016)	Statistically significant effects of SAQ in Ex 1 group.	N=30 3 groups: Ex1 (n=10) Ex2 (n=10) Con (n=10)	14-17	Both gender	Illinois test	Program (3 times a week for 60 min): Ex1 - SAQ training group Ex2 -circuit training group group Con - did not participate in any training program	12 weeks

McCormick et al. (2016)	Statistically significant effects of FPP in Ex 1 group.	N=14 2 groups: Ex1 (n=7) Ex2 (n=7)	15-16	female	1. Lateral hop test left (LHTL) 2. Lateral hop test right (LHTR) 3. Lateral Shuffle Test left (LSTL) 4. Lateral Shuffle Test right (LSTR)	Program (twice per week): Ex1 - a frontal-plane plyometric program (FPP) Ex2 - a sagittal-plane plyometric program (SPP)	6 weeks
Sangari & Annadurai (2017)	Statistically significant effects of plyometric Circuit training in Ex group.	N=30 2 groups: Ex1 (n=15) Con (n=15	18-25	Both gender	Illinois test	Program (three times a week for 60 min): Ex1 - Plyometric Circuit Training Control group - Regular basketball training	12 weeks
Asadi et al. (2017)	Statistically significant effects of plyometric training in Ex group.	N =16 2 groups: Ex (n = 8) Con (n = 8)		Both gender	T- test Illinois test	Program (3 times a week): Ex - a plyometric with regular basketball training Con - Regular basketball training	8 weeks
Ichrak, Yassine, Roy & Souhaie (2018)	Statistically significant effects of combined training in Ex group.	N=26 2 groups: Ex (n = 16) Con (n = 10)	16 -17	Female	Illinois test	Program (2 times a week): Ex - combined balance and plyometric training sessions. Con - basketball training	8 weeks

DISCUSSION

In this systematic review of 32 papers, the available literature related to training methods and agility in basketball players were critically reviewed and analysed.

In all the analyzed studies, the most common was to have one experimental and one control group (Ivković, 2007, Chaudhary & Jhajharia, 2010, Bal, Kaur & Singh, 2011, Boccolini, Costa & Alberti, 2012, Asadi & Arazi, 2012., Živković, 2012., Orhan, 2013., Asadi, 2013, Dadwal, 2013, Poomsalood & Pakulanon., 2015, Atanasković, Georgiev & Mutavdzić, 2015, Asadi et al., 2017 and Ichrak, Yassine, Roy & Souhaie, 2018). Two experimental groups that realized different experimental programs were in the studies of Andrejić (2012), Arazi, Coetzee & Asadi (2012), Gottlieb, Eliakim, Shalom, Dello-Iaconob & Meckel (2014), Ramateerth & Kannur (2014), McCormick et al. (2016) Saraswat, Malhotra & Sivaram, (2015) and Sangari & Annadurai (2017). Three experimental groups of participants without control group were in study of Shaji & Isha (2009), while three groups of participants that included two experimental and one control group were in the studies of Nandalal, (2013) Mitra, Bandyopadhyay & Gayen (2013), Parimalam &Pushparajan (2014) Diswar, Choudhary & Mitra, 2016.

Five studies (Shallaby, 2010., Lehnert, Hůlka, Malý, Fohler & Zahálka, 2013) were realized with only one group of participants.

Experimental groups included those groups in which basketball players accomplished certain training programs to develop different motor abilities among which is agility. Control groups of participants were not included in training program but they realized either regular physical education program (Ivković, 2007) or standard basketball training (Chaudhary & Jhajharia, 2010; Shallaby, 2010; Boccolini, Costa & Alberti, 2012; Asadi & Arazi, 2012; Živković, 2012; Orhan (2013); Nandalal, S. (2013); Asadi (2013); Dadwal, 2013; Mitra, Bandyopadhyay & Gayen, 2013; Parimalam & Pushparajan, 2014; Poomsalood & Pakulanon, 2015; Atanasković, Georgiev & Mutavdzić, 2015; Abraham, 2015, Diswar, Choudhary & Mitra, 2016; Asadi et al., 2017 and Ichrak, Yassine, Roy & Souhaie, 2018.

The experimental program for each study was defined by the frequency of exercise, that is the number of workouts per week and during the overall duration of the experimental period, the type of workout, and the time of duration of each individual workout. The intensity, that is, the level of physical activity wasn't defined. The length of the experimental program was from 2 weeks (Ramachandran & Pradhan, 2014) up to 12 weeks (Shallaby, 2010; Boccolini, Costa & Alberti, 2012; Parimalam & Pushparajan, 2014).

The physical activity programs mainly consisted from the various training activities, such as plyometric training program which was applied in the research of Chaudhary & Jhajharia, (2010), Shallaby, (2010), Bal, Kaur & Singh, (2011), Asadi & Arazi, (2012), Nandalal, (2013); Lehnert, Hůlka, Malý, Fohler & Zahálka, (2013); Asadi, (2013; Dadwal, (2013); Mitra, Bandyopadhyay & Gayen, (2013), Gottlieb, Eliakim, Shalom, Dello-Iacono & Meckel (2014), Poomsalood & Pakulanon, (2015), Abraham, (2015), Kamani & Nikseresht (2015), McCormick et al., (2016) and Sangari & Annadurai, (2017) and combined plyometric training program with other popular training modalities (e.g. strength/sprint/dynamic stretching/aerobic endurance/) as it was in the research of Shaji & Isha, (2009), Nandalal, (2013), Mitra, Bandyopadhyay & Gayen, (2013), Gottlieb, Eliakim, Shalom, Dello-Iacono & Meckel, (2014), Zarić, 2014; Ramachandran & Pradhan, 2014; Ramateerth & Kannur, 2014; Abraham, (2015) and Ichrak, Yassine, Roy & Souhaie (2018).

Beside the effects of plyometric and combined plyometric training programs, the effects of the following training programs were also investigated: clasic basketball training (Ivković, 2007), rope jump training (Boccolini, Costa & Alberti, 2012; Orhan (2013), proprioceptive training (Živković, 2012), basketball specific training and traditional method of training (Parimalam & Pushparajan, 2014), school sports activities (Badrić, Prskalo i Sporiš, 2015), balance training (Saraswat, Malhotra & Sivaram, 2015), vibration training (Atanasković, Georgiev & Mutavdzić, 2015) and combination of circuit and SAQ training (Diswar, Choudhary & Mitra, 2016).

The control groups of participants did not deal with any special training program but they were included in regular physical education teaching (Ivković, 2007), standard basketball program (Chaudhary & Jhajharia, 2010; Shallaby, 2010; Boccolini, Costa & Alberti, 2012); Asadi & Arazi, 2012; Živković, 2012; Orhan, 2013; Nandalal, 2013; Asadi, 2013; Dadwal, 2013; Mitra, Bandyopadhyay & Gayen, 2013; Parimalam & Pushparajan, 2014; Poomsalood & Pakulanon, 2015; Atanasković, Georgiev & Mutavdzić, 2015; Abraham, 2015; Diswar, Choudhary & Mitra, 2016; Asadi et al., 2017, Ichrak, Yassine, Roy & Souhaie, 2018) and intercollege basketball competitions (Bal, Kaur & Singh, 2011). Training programs were accomplished at schools, sport centers or training grounds.

The number of participants per study ranged between 10 in the research of Badrić, Prskalo & Sporiš, (2015) and Poomsalood & Pakulanon, (2015) and 60 in the research of Ivković, (2007), Mitra, Bandyopadhyay & Gayen, (2013)

The studies included males (17), females (7) and participants of both gender (8). The youngest participants were in the study of Ramateerth & Kannur, (2014), at the age of 12-13, and the oldest participants were 25 years old in the study of Chaudhary & Jhajharia, (2010).

CONCLUSION

By analyzing the obtained results, it can be concluded that the plyometric training is a very popular and very effective form of physical conditioning in both gender athletes. Numerous studies showed that plyometric training (in water or land surface) significantly improved the change of direction performance and that the mean effects depended on the type of change of direction test measured.This method has been extensively studied over the last decades. The balance training, the rope jump training as well as the combined plyometric training with other popular training modalities were also efficient compared to vibration training which was not so efficient.

On the bases of the obtained results it can be assumed that there are a positive transfer of the effects of plyometric training on change of direction ability in basketball players as well as that when subjects can perform plyometric exercises with adequate technique and have good fitness level, the training gains are better. A number of studies found that plyometric training, which lasts 6 weeks (with 2 or 3 sessions per week) leads to a significant improvement of agility in players. A short-term plyometrics has the potential to enhance a wide range of athletic performance (i.e. jumping, sprinting and agility) in children and non-athletes but not in elite players.

Another important conclusion is that there is a minimal profit to perform vibration training, and that it is more beneficial to combine plyometrics than to utilize only the single modality. The effects of plyometric methods could vary because of a large number of variables, such us program duration, training volume, rest interval or intensity and subject characteristics (gender, age). These variables should be taken into account by strength and conditioning professionals to design an optimum plyometric program to enhance change of direction ability in athletes.

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Interdisciplinary

FORCE-VELOCITY RELATIONSHIP OF LOWER-BODY MUSCLES DURING HORIZONTAL JUMPS-PRELIMINARY RESULTS

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SUMMARY

The vertical jump is one of the functional tasks most commonly used for exploring the F-V relationship of lower-body muscles. The main issue with vertical jump testing is that the experimental points used for the F-V modelling are force-biased. Therefore, this study aimed(I) to explore whether the F-V relationship of lower-body muscles remains linear when points closer to the velocity-intercept are considered and (II) to compare the reliability of the F-V relationship parameters between the vertical and horizontal jump testing procedures. We hypothesized that (I) the linearity of the F-V relationship would be high for both jumping modalities and (II) the F-V relationship parameters would be obtained with higher reliability from the horizontal jump testing procedure due to the use of more distant loads. Results showed that (1) F-V relationship is linear for both vertical ($r \geq 0.999$) and horizontal jumps ($r \geq 0.999$), and (2) that there were no significant differences in reliability between same F-V parameters [F_0 (CV≤8.05% and ICC≥0.93), a (CV≤14.01% and ICC≥0.92), V_0 (CV≤8.09% and ICC≥0.86) and P_0 (CV≤7.45% and ICC≥0.92)]. After a thorough familiarisation procedure horizontal jumps can be used for exploring mechanical capacities for the lower-body muscles using F-V relationship modelling.

Keywords: Linearity, Reliability, Vertical jumps, F-V relationship parameters

INTRODUCTION

The linear modelling of the force and velocity data recorded under twoor more loading conditions allows determining the distinctive capacities of the muscles to produce maximal levels of force (F_0), velocity (V_0) and power (P_0) (García-Ramos & Jaric, 2018). The vertical jump is the tasks most commonly used to explore the F-V relationship of lower-body muscles (Cuk et al., 2014; Feeney, Stanhope, Kaminski, Machi, & Jaric, 2016). However, the accuracy of the F-V relationship obtained from routinely applied vertical jump testing procedures could beslightly compromised (due to the narrow range of loading conditions), which may limit the practical applications of the F-V relationship.

The main shortcoming of the testing procedure routinely applied for assessing F-V relationship of vertical jumps is that the experimental points used for the F-V modelling are force-biased (i.e., closer to the force-intercept than to the velocity-intercept) (Cuk et al., 2014; García-Ramos, Feriche, Pérez-Castilla, Padial, & Jaric, 2017). In particular, the minimal loading condition applied during vertical jump testing procedures, typically the subject's own body mass, provides a point close to the middle part of the F-V relationship (García-Ramos et al., 2017; Jiménez-Reyes, Samozino, Brughelli, & Morin, 2017; Samozino, Rejc, Di Prampero, Belli, & Morin, 2014) hence compromising the accuracy of the later obtained F-V parameters. Accuracy of the determination of F_0 and V_0 is compromised when the experimental points are far from the intercepts (García-Ramos & Jaric, 2018; Pérez-Castilla, Jaric, Feriche, Padial, &

García-Ramos, 2017). Therefore, there is an apparent need to make adjustments in the standard testing procedure used to determine the F-V relationship through vertical jumps, so thatpoints closer to the velocity-intercept could be obtained and accuracy of the parameter estimates increased.

Horizontal jumps (squat jump performed while participants laid down on a custom made roller device) could represent a viable option to provide experimental points more proximal to the velocity-intercept by limiting the influence of gravity. Although the F-V relationship has been described as highly linear for various types of vertical jumps (Cuk et al., 2014; Feeney et al., 2016; García-Ramos et al., 2017; Jiménez-Reyes et al., 2017; Samozino et al., 2014), it is unknown whether the F-V relationship remains linear when points close to V_0 are considered. Horizontal jumps may provide a more accurate F-V relationship than vertical jumps by incrementing the distance between the experimental points as well as by bringing the experimental points closer to V_0(García-Ramos & Jaric, 2018). More, horizontal jumps presents a safer alternative for assessing mechanical capabilities of lower-limb muscles. In this way, older people, children and rehabilitation patients can participate in this type of testing. However, it remains to be elucidated which jumping modality (vertical vs. horizontal) provides the F-V relationship parameters with higher reliability.

In an attempt of overcoming the main limitation of vertical jumps for testing the F-V relationship (i.e., the experimental points are force-biased), the present study explored the feasibility of maximal horizontal jumps for assessing the F-V relationship of lower-body muscles. Specifically, the objectives of the present study were (I) to explore whether the F-V relationship of lower-body muscles remains linear when points closer to the velocity-intercept are considered and (II) to compare the reliability of the F-V relationship parameters between the vertical and horizontal jump testing procedures. We hypothesized that (I) the linearity of the F-V relationship would be high for both jumping modalities and (II) the F-V relationship parameters would be obtained with higher reliability from the horizontal jump testing procedure due to the use of more distant loads.

METHODS

Subjects

Six men sport sciences students (age: 23.1 ± 3.2 years; body mass: 74.7 ± 7.3 kg; height: 1.77 ± 0.07 m) voluntarily participated in this study. All participants were physically active through their academic curriculum, which included approximately eight physical activity classes per week, but none of them was a professional athlete. Selection criteria included (I) being able to perform a deep squat with a proper technique, (II) being able to jump more than 10 cm with an external load of 40 kg during the squat jump (SJ) exercise, and (III) not suffering from pain or recent injuries that could compromise testing. All participants were informed of the procedures to be utilised and signed a written informed consent form before the initiation of the study. The study protocol adhered to the tenets of the Declaration of Helsinki and was approved by the Institutional Review Board.

Procedure

All participants were tested in 3 sessions separated by 48-72 hours. Session 1 was used to familiarise the participants with both jumping modalities as well as to determine the maximum loads to be applied during the 2 remaining testing sessions. Sessions 2 and 3 consisted of maximal vertical and horizontal jumps performed against 5 different external loads to determine the F-V relationships during both jumping modalities. All testing sessions were performed at the same time duringthe day for each participant. Standardised warm-up consisted of 5 min of cycling and joint mobility exercises. Following the warm-up, the participants randomly performed an incremental loading test during the vertical and horizontal jumping modalities. The external load was arbitrarily incremented from the minimal possible loading condition until the load associated with a jump of 10 cm was reached(this was the maximum load applied during the sessions 2 and 3). Vertical jump height was assessed by means of a validated iPhone application (Myjump2) (Balsalobre-Fernandez, Glaister, & Lockey, 2015). Horizontal jump distance was assessed with a linear position transducer, which was attached to the first block of the lat machine, subtracting the displacement recorded during the jump to the push-off distance. A range of 4-6 different loads were applied during both incremental loading tests with 3 min of rest between loading conditions.

Vertical jump testing procedure: The SJ was performed with a free-weight barbell over the participants' shoulders. All jumps were performed on a force platform (AMTI BP600400, Advanced Mechanical Technology, Inc. Watertown, MA 02472-4800 USA) that sampled the vertical component of the ground reaction force (GRF) data at a frequency of 1 kHz.*Horizontal jump testing procedure:* Participants laid down on a roller device (mass = 12 kg) with their feet in contact with a force platform that was vertically positioned and with their arms fully extended holding handles that were fixed at each side of the roller device.The maximum force and velocity data recorded under 5 different loading conditions were used for the assessment of the F-V relationship parameters through a linear regression model: [$F(V) = F0 - aV$], where F0 represents the force-intercept and a is the slope of the F-V relationship. They enabled the calculation of $V0$ (velocity-intercept; $V0 = F0/a$) and P_{max} (maximum power; $P_{max} = (F0 \cdot V0)/4$). Only the trial with the highest maximum velocity at each load was used for the F-V modelling.

Statistical analysis

Qualitative interpretations of the *r* coefficients are provided for all significant correlations (0.00–0.09 trivial; 0.10–0.29 small; 0.30–0.49 moderate; 0.50–0.69 large; 0.70–0.89 very large; 0.90–0.99 nearly perfect; 1.00 perfect) (Hopkins, Marshall, Batterham, & Hanin, 2009). Reliability was assessed by the coefficient of variation (CV) and the interclass correlation coefficient (ICC) with their 95% confidence intervals. Acceptable reliability was determined as a CV<15% and an ICC>0.70. The Pearson's correlation coefficient (*r*) was used to explore the association between the same variables obtained during vertical and horizontal squat jump. Statistical analyses were performed using Excel Microsoft Office, 2013. Alpha was set at 0.05.

RESULTS

Linearity of the F-V relationship

The F-V relationships were strong and linear, obtained either from the vertical jumps (r ≥ 0.999) or from horizontal jumps (r ≥ 0.999) (Figure, 1).

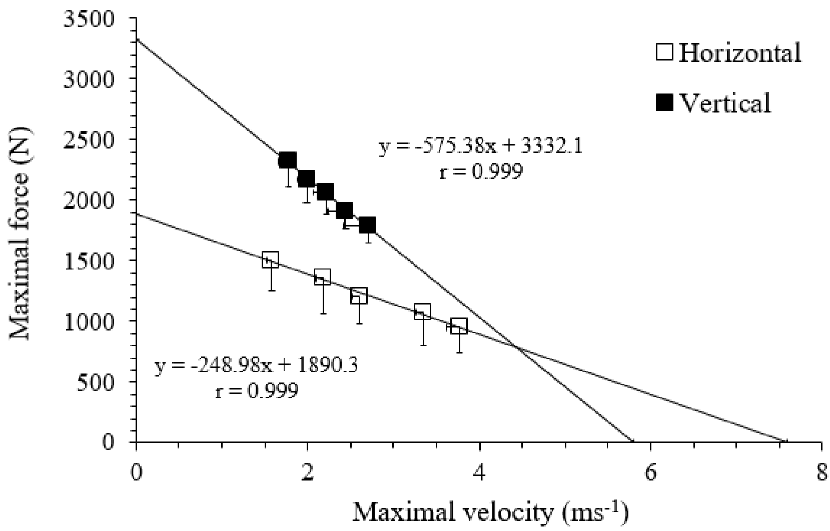

Figure 1. Force-velocity relationship obtained during horizontal and vertical jumps

Intra-day reliability of the F-V parameters

Correlation coefficients obtained between same F-V relationship parameters were from very large to nearly perfect [Vertical jumps: F_0=0.95; a=0.91; V_0=0.76; P_0=0.90; Horizontal jumps: F_0=0.90; a=0.84; V_0=0.86; P_0=0.85]. Regardless of the SJ type and the load considered, an acceptable reliability was observed for F_0 (CV≤8.05% and ICC≥0.93), a (CV≤14.01% and ICC≥0.92), V_0 (CV≤8.09% and ICC≥0.86) and P_0 (CV≤7.45% and ICC≥0.92). In overall, no systematic differences in reliability were identified across the two vertical and horizontal jump type.

Tabele 1. Intra-day reliability of the F-V relationship parameters

Jump type	Parameter	Trial 1	Trial 2	CV (90% CI)	ICC (90% CI)
Vertical jumps	*F0 (N)*	3309.5 (407.0)	3476.2 (416.6)	2.61 (1.76, 5.46)	0.98 (1.76, 5.46)
	V0 (m·s-1)	6.0 (0.8)	5.6 (0.7)	6.3 (4.23, 13.16)	0.86 (0.46, 0.98)
	a (N·s·m-1)	565.1 (131.0)	627.7 (122.8)	6.27 (4.21, 13.08)	0.96 (0.83, 0.99)
	P0 (W)	4921.7 (598.5)	4870.9 (668.3)	4.04 (2.72, 8.45)	0.96 (0.81, 0.99)
Horizontal jumps	*F0 (N)*	1893.5 (393.0)	2032.2 (469.8)	8.05 (5.41, 16.81)	0.93 (0.69, 0.99)
	V0 (m·s-1)	8.1 (1.8)	7.6 (1.4)	8.09 (5.44, 16.9)	0.92 (0.67, 0.98)
	a (N·s·m-1)	250.4 (89.3)	282.3 (97.1)	14.01 (9.41, 29.27)	0.92 (0.66, 0.98)
	P0 (W)	3738.8 (743.5)	3747.3 (663.6)	7.45 (5.0, 15.56)	0.92 (0.67, 0.98)

F_0, maximum force;V_0, maximum velocity; *a,* slope; P_0, maximum power; CV, coefficient of variation; ICC*,* interclass correlation coefficient; Data are presented as mean (SD) for trials, and as mean (95% CI) for CV and ICC;

DISCUSSION

This study was designed to explore whether the F-V relationship of lower-body muscles remains linear when points closer to the velocity-intercept are considered, and to compare the reliability of the F-V relationship parameters between the vertical and horizontal jump testing procedures. Results showed that F-V relationship is linear for both vertical and horizontal jumps, and that there were no significant differences between same F-V parameters.

Supporting our first hypothesis, both jumping modalities showed high linearity of the F-V relationship. This is in line with other studies where it has been shown that F-V relationship is strong and linear within multi joint movements (Garcia-Ramos & Jaric, 2018; Jaric, 2015; Zivkovic, Djuric, Cuk, Suzovic, & Jaric, 2017).Differences in the slope of F-V relationship suggest that jump types used in the current study provide distinct muscle mechanical properties. Specifically, higher forces obtained during vertical jumps could be potentially explained by higher contribution of the lumbar extensors, however this is yet to be explored. Nevertheless, our findings suggest that F-V parameters obtained during vertical jumps,cannot be generalized for horizontal jumps, and vice versa. More, vertical jumps could be more useful for exploring maximal force capacities, while horizontal jumps for assessing velocity capacities of the participants. The strong linearity of the F-V relationship observed during horizontal jumps opens the possibility of using the two-point method for a quicker determination of the F-V relationship during horizontal jump type(Grbic et al., 2017; Pérez-Castilla, Jaric, Feriche, Padial, & García-Ramos, 2017).

Even though reliability of the F-V parameters wasacceptable for both vertical and horizontal jumps, we found no systematic differences between the same F-V parameters. This means that, contradicting our hypothesis, applying points closer to the interceptswas not enough to increase reliability of the F-V parameters, like reported in the study of Garcia et al. (García-Ramos & Jaric, 2018). It should be noted that this exercise present a novelty for our subjects which could compromise reliability. Nevertheless, acceptable reliability, like one of the most important characteristic of test, allows further exploration of the nature of F-V relationship during horizontal jumps. Future research should try to explore difference in reliability between vertical and horizontal jumps, but after longer familiarisation period.

CONCLUSION

The F-V relationship is linear for both vertical and horizontal jumps, and that there were no significant differences between the same F-V parameters. After familiarisation procedure, horizontal jumps can be used for exploring mechanical capacities for the lower-body muscles using F-V relationship modelling, as it is safer option for testing general population.

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A STYDY OF VOJTA THERAPY EFFECT ON INFANT CHILDREN WITH DEVELOPMENTAL MOTOR DISORDER

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SUMMARY

Infants with a neuromotor developmental disorder in neuromotor development are those newborns at risk (prematurely born) whose life and health are endangered by various unfavorable factors occurring before and during their birth and in the neonatal period. Vojta therapy "Reflex locomotion" is associated with accurately defined axis and limb movement processes that can be affected in a reflexive way by certain trigger zones while preserving a particular initial position.

Keywords: Vojta therapy, infancy, premature, neuromotor development.

INTRODUCTION

Vojta therapy is a method that impacts infant's overall movement coordination. The basic patterns are programmed genetically in each individual's central nervous system (CNS). They serve as building (Amagasa, Tsuji, Matsui, Uematsu, Moriya, & Kinoshita 2017). Therapy is based on developmental kinesiology including individual developmental stages, such as a stable supine position. First head lifting in prone, rolling, side sitting, erect sitting, creeping, standing and walking are assessed not only in their final static state, but also how this change from one position to the next occurs and which muscles are activated in the process. There are three integral components to locomotion (forward movement): automatic control of body position, trunk verticalization against gravity and with it corresponding phasic mobility , which is manifested by a grasping and stepping forward movment of the extremities (Kolář, P.,2013). A specific input from the periphery (aferentation) causes a specific motor response (efferentation). In certain starting positions of specific body areas, a manual applications of pressure is applied to the trigger zones. Trigger zones serve for elicitation of automatic locomotor movements, which the author labeled reflexive crawling and turning. After a period of stimulation, summative zone stimulation can elicit a complex motor reaction. These motor responses are not random, but legitimate and consistent. Individual movement patterns resemble movement that leads the individual to an erect body posture and walking (Václav, & Peters, 2007). The spontaneous connection of these innate movement patterns is limited due to CNS and movement system dysfunction. The CNS can be activated through reflex locomotion thereby "awakening" from the disturbed condition in order to renew the innate physiological movement patterns (Vojta, & Peters, 2003).

METHODS

The contingent of study is 16 infants at risk (prematurely born), 8 boys and 8 girls, aged 3 months. Adjusted age has been taken into account (Weindling, 2002). Infants have an initial diagnosis of "Central Coordination Disorder (CCD)" (In the neonatal and infantile stages, knowledge of motor behavior during CNS development (motor patterns) and its variability are used in the assessment of motor functions. Neuromotor developmental screening is a basic stepping stone for early identification of children with a CNS dysfunction. Children who demonstrate an abnormal model of spontaneous motor behavior and positional reactions are included in a clinical category referred to as a central coordination disturbance (CCD)), (Hellbrügge, 2012). "CCD" - First and Second degree, according to Vojta's diagnostic scale. Five of them have I degree and 12 - II degree of CCD. The infants have been divided into two groups by sex. The first group comprised of 8 infants at risk (boys). The second group also comprised of 8 infants at risk (girls). Metric indicator for observation that has been used: Measurement Test for Gross motor function measure (GMFM) -"Lying and rolling"., (Palisano, Rosenbaum, Bartlett, & Livingston, 2007). The dynamics of neuromotor development has been studied at the beginning of the 3rd month and at the end of the 6th month. The choice of this age group is due to the fact that during the second trimester of infancy, the infantile CNS gradually shifts from phylogeny to ontogenesis, and changes in developmental dynamics are most distinguishable and easily observed (Fawke, 2007).

STUDY'S OBJECTIVE

To investigate the effect of Vojta therapy on infants with neuromotor disorder in early infancy.

Procedure

The therapeutic session has duration of 15-20 minutes and is applied daily. The infant's mother has a critical role in the therapeutic team (Hellbrügge, 1995). She goes through an appropriate preparation and performs the home therapy 3 - 4 times a day (Vojta, & Peters, 2003).

To elicit a purposeful response through spontaneous reflex movement, we use two types of reflex locomotion: Reflexive turning (RT) and Reflexive crawling (RC). Reflex movement models are complete patterns, and when performing these movements, all muscles are activated with proper coordination. Different levels of CNS are involved in this activation. In this way, the brain "trains" to administer the movements properly (Kolář, 2013).

Pic.1 Phase 1- RT– Supine position

Pic.2 Phase 1- RT - Side position

Pic.3 Reflexive Crawling

STATISTICAL ANALYSIS AND RESULTS

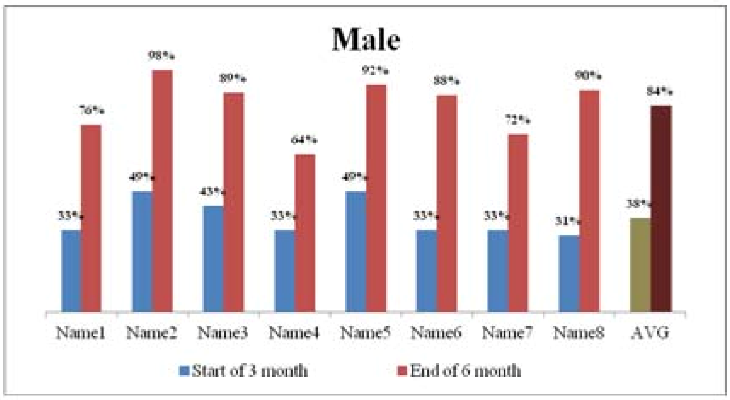

Fig.1. Boys'Graphics (*Male*) Difference in movement from the beginning to the end of the observed period.

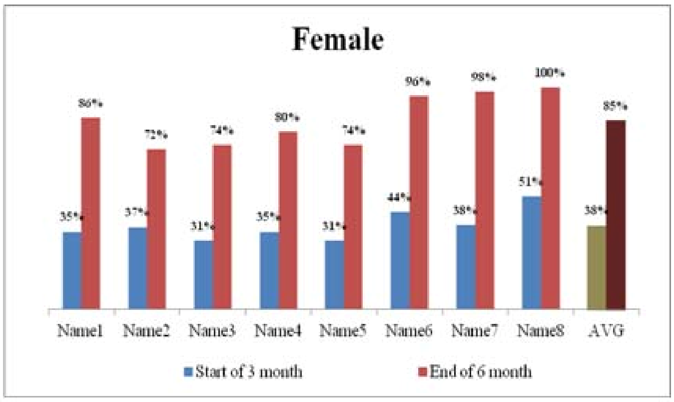

Fig.2. Girls' Graphics (*Female)* Difference in motion from the beginning to the end of the observed period.

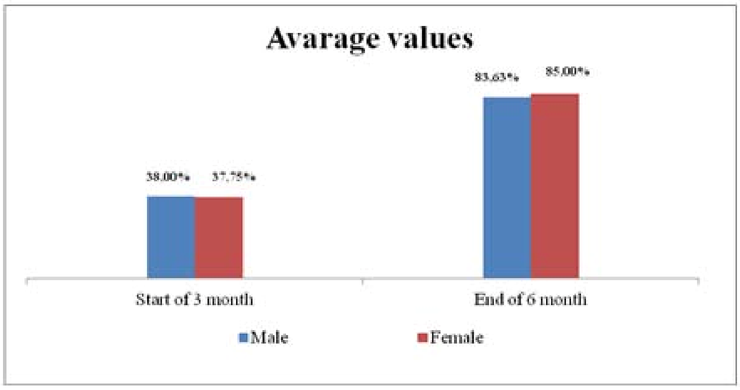

Fig.3. Average results for *Male* and *Female*.

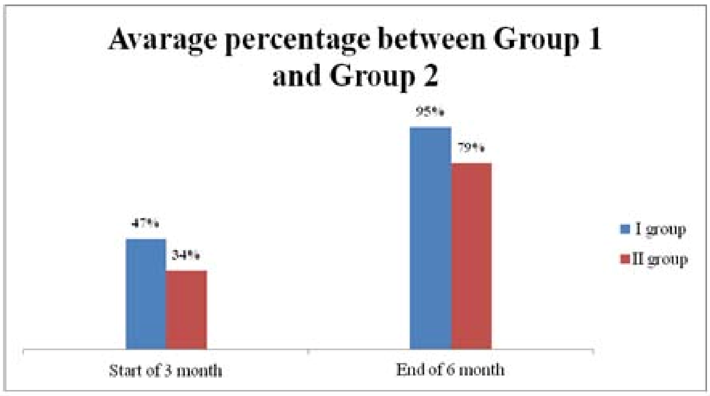

Fig.4. Average results between *Group 1* and *Group 2*. Results from the beginning of 3m. of therapy until the end of 6m.

DISCUSSION

Early evaluation and detection of the neuromotor developmental disorder is a complex problem that requires special knowledge of the physiological and pathological neuro-motor development. The early detection and diagnostics allow to start rehabilitation at the proper time thus providing greater treatment effects. The study is based on the physiological concept of Vojta therapy, which is through reflex locomotion to automatically awaken "flickering" or "blocked" motor skills and to integrate these capabilities. According to Vojta, 90% of children with CCD I degree spontaneously normalize, about ¾ of the children with CCD II grade also normalize spontaneously, but most often they only need treatment due to the future postural disorder. (Kolář, P., 2013). Our results support the concept.

The use of therapy in the second trimester of infancy provides good results and prospects for neuromotor development (Yancheva, S. 2013).

CONCLUSION

Vojta therapy has a positive impact on overall motor development. The cross-sectional muscles of the whole body are activated in certain coordination and all levels of CNS participate. In this connection, the development of bones and joints is beneficial. Muscle groups that are activated in therapy include abdominal muscles, diaphragm, back muscles and trunk muscles. This improves breathing and blood circulation (Bobev, & Genev, 2000). The brain is extremely susceptible to impacts during infancy period due to its neuroplasticity and is able to compensate for problems when aided by appropriate intervention (Flehmig, 2007).

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AUTONOMY IN SPORT - MYTH OR REALITY, OPPORTUNITY OR ILLUSION

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SUMMARY

The non-uniform nature of the sport relations subject to regulation of the sport law predetermine the different nature of the regulation, that suggests different type of "autonomy" of the sport organizations. The study examines topical issues on the autonomy in sports and the normative mechanisms for regulation. The uneven nature of sporting relationships, which are subject to regulation of sport law, predetermines the different nature of regulation, which in turn provides for a different "autonomy" of sports organizations. In order to solve the main tasks, the achievement of the goal and the proof of the hypotheses, a method of literary sources and content analysis was applied.

Keywords: public regulation, management methods, regulation, sport.

INTRODUCTION

The casual character of relationships in sport which are subject to regulation of sport law predetermine different kind of regulation, which in turn presupposes different "autonomy" of sports organizations. The problems concerning the autonomy of sports entities on the one hand are insufficient means in the public sector for sport from other corruption and organized meetings in sport. The study examines actual issues related to sport autonomy as well as regulatory mechanisms for regulation.

The term autonomy derives from the ancient Greek independent, someone who gives himself his own right, it is associated with synonyms such as self - independence, autonomy, self-rule of a community [http://lib.sportedu.ru].

According to Koleva (1997, 14-15), "in general, the existence of rights and the ability of a social subject (group, organization, and individual) to organize and direct their actions independently within the social entity to which they belong". From a sociological point of view, autonomy can be interpreted in the context of the concept of determinism or social order.

Thomas Hobbes explains the problem of social order as follows: man is a human being whose behavior in the short life of his existence is determined by some inherent qualities of human nature - rivalry, distrust, and the pursuit of power. Although people were born and die equal, as a result of their behavior there is inequality in society and they live in this context of social inequality. Because of rivalry, mistrust and aspiration to power that are the natural state of people's lives is "War of Everyone Against Everyone". These prerequisites raise the question: how is it possible that these social organization and order has been established and maintained constantly and what basis they are created on? (Hobbes, 1971).

The contemporary situation of sociological knowledge assume that the problem of social order could be formulated in the following way: how can durable and adjustable social relations between social actors who have opposite interests and different resources be created, operated, preserved and changed (Conev, 2013; Barazgova, 1997; Ivanov, 1989).

In summary, the term social order can be seen as well-established rules and mechanisms for coordinating roles and institutions. And the concept of social role as a combination of prescriptions in terms of rights and obligations outlining the boundaries of human behavior as corresponding to a particular position or the so-called status (Dimitrova, 2017).

The scientific analysis, according to Fotev (2004), reaches the autonomy of the structure that is experienced and experienced in terms of everyday life by individual and collective agents (natural/ physical persons and juridical persons). According to value or consensus theories, the main mechanism for the maintenance of social order in society is socialization (Kolarova, 1997), which is primary and secondary.

The principle of autonomy in sport applied by public authorities, according to a number of authors dealing with legal regulation in sport, is one of the most important principles which the whole system of sport is built on (Ng, 2010; Mazzucco, 2010).

The term autonomy in sport emerged in 1949 in the Olympic Charter and has a direct impact on national Olympic committees (Chappelet, 2009). According to Jacques Roger, Chairman of the International Olympic Committee (2001-2013), the protection of autonomy in sport is fundamentally important because it is based on the unique nature of sport, on commonly accepted principles such as fair play and competitiveness at global level. International organizations active in the sphere of sport can be divided into organizations with general and specific competence. The organizational division in the sphere of sport is realized through different regulation in the sphere of: social, stores and travel relationships. When they relate to sports. Also sports law regulates the activity of all main legal entities: 1. Gender as a physical subject of the law; 2. Organizations of citizens as legal entities; 3. State and local authorities; 4. International sports organizations – institutions (Zakon za uridicheskite lica s nestopanska cel, 2016).

In summary, the organizational division is implemented through sport law and governs the regulation of sporting social relations, from public authorities and sports organizations, the realization of this regulation as rights and obligations and the legal order in the field of sport. It should not be forgotten that the unnecessary interference by the public authorities could easily break the principles of sport (Pigeassou, & Garrabos, 1997).

OBJECTIVE AND TASKS OF THE STUDY

The aim of the scientific research is to reveal some legal and sociological aspects of the autonomy in sport and some features of their manifestation on national and global scale. The idea of autonomy consists in requiring a person to obey only those norms that he himself gives or at least voluntarily accepts as reasonably justified.

The aim of this publication is to enhance the theoretical and practical knowledge and competencies of real and potential users (specialists, students, sportsmen).

The specific objectives are the following: to reveal and analyze interpretations and varieties related to the term autonomy in sport from legal and sociological point of view; determine the main negative trends influencing the studied problem; identify good practices relevant to the autonomy in the field of sports; to draw conclusions and recommendations on the theory and practice of sports activities in order to prevent deviant behavior in sport (it is not necessarily that sports organizations have autonomy but within the law).

Study hypotheses: we assume that the research will reveal various problems and variations related to the term autonomy in sport and its peculiarities of manifestation on national and global scale; we assume that the scientific work will contribute to the improvement of the theoretical and practical knowledge, the legal awareness of citizens and officials, and the acquisition of skills to use the rule of law.

In order to resolve the main tasks, the achievement of the goal and the proof of the hypotheses, a method of study of literary sources and content analysis was applied.

Content analysis is the most appropriate method to determine changes in social values and norms, in images and stereotypes of the "other" (Diekmann, 1998). The method goes beyond the text and focuses on the social context, the social norms and values transmitted through the text. Understanding social roles and patterns of behavior mastering forms, values, symbols, norms, traditions, languages, meanings and other cultural values; acquiring own socio-cultural experience and personal (social, ethnic, professional, etc.) identity; achieving autonomy and autonomy in the individual's individual behavior. They are marked by reading texts and compared with those expressed in other texts. "Content-analysis is a specific technology (include an analysis of policy measures) for detailed document study and quantification of its content" (Mateeva, 2002, 202). The technology include an analysis of policy measures. The research was conducted between May 2015 and April 2017.

ANALYSIS OF THE RESULTS AND DISCUSSION

In general, the normative level is represented by two forms of regulation of the people's social actions: institutional and non-institutional. They are also valid for the field of sports as a whole with their specifics but also act in parallel at it and at social level.

According to Stepanenko (Stoichev, 1996), there are two types of norms: universal, which are accepted by all members of society without restrictions, and special ones that regulate the activities of the individual groups.

It is typical for universal norms that they rely on prescriptions and requirements directly related to the generally separable system of values and often have a legal, legislative basis. In sport have a special law governing sporting relationships - a sports law, and these norms are complemented by organizational frameworks for specific procedures and include: principles of functioning, differentiation and interdependence of different sports associations; principles of participation, roles' distribution and change of positions; rules on remuneration and punishments, success and defeat; offset the effort on the way to its own sports goals.

Special regulations refer to certain social and professional groups such as youth, teachers, coaches, doctors, and others (according to the national classifier have different requirements).

In sports, the laws and codes of conduct of individual disciplines that control the behavior of the contestants and partners are analysed, and the general principle is often presented as a collection of methanorms. These may be so-called Olympic values and goals, but they also include the old Scout slogan "to consider life as a game, and the world as a playground" (Albonico et al., 1971).

According to André-Noël Schaeke, autonomy in sport is one of the three key principles in this field, followed by solidarity and the principle of partnership between public authorities and sports organizations (Chappelet, 2010).

After 1990 the change of the political model of government in Bulgaria and the emerging crisis in the country, sport clubs became autonomous as for example the shop, previously there was a monopoly of the state and in sport. There has been an opportunity to register under the Commercial Act as Joint Stock Companies which were created. This has brought many sports clubs to the brink of survival, and governing of sports federations has been associated most often with authoritarian and not so democratic governance, corruption and scrutiny.

Corruption in FIFA has already been proven, inform world agencies. Former vice president of the headquarters, Juan Angel Naput, and former president of the Brazilian Football Confederation, José María Marin, were found guilty by the New York court.

They have taken bribes in exchange for awarding marketing and media rights to international football matches [https://topsport.bg/other-football/koruptsiyata].

According to National Strategy for the Development of Physical Education and Sport in the Republic of Bulgaria 2012-2022, the main strategic goal of the system is promotion of physical education, sport and social tourism as means of improving the health and physical capabilities of population, increasing the number of those practicing organized sports for all, as well as raising the world's sports prestige of Bulgaria [http://rechnik.info].

There have arised several questions about autonomy, especially about the autonomy of sport itself. What is the mechanism of autonomy and, therefore, what is the legal basis for this autonomy?

There has been paid an insufficient attention in Bulgarian legislation to the considered issues under. In terms of current law on sport, the state encourages the creation and the functioning of sports organizations. If there is a special law, it is logical that all these sports organizations have been registered (can be registered under the trade law and by law for non-profit legal entities).

On one hand, we have a non-profit organization with additional requirements in the Physical Education and Sport Law (Serdiukov, 2010; Zakon za fozicheskoto vaspitanie i sporta, 2016).

The sport's strategy provides legal changes guaranteeing differentiated minimum size of each citizen's financial sum for sport. The autonomy of sport is again not on the agenda.

The question of the autonomy of sport in Bulgaria and not only in our country is relevant for number of reasons, and it is so because we have witnessed many questionable or arranged matches. First of all whether it has or is only legally regulated under the law, and secondly, great autonomy leads to violation or circumvention. The question raise and the answer emerged, and we ask where is this autonomy or directly it is missing? According to Jean Cornell, this is just a kind of cover for business interests in the entertainment industry and sports (Bach, 2009).

Other authors are not so extreme in their opinions and have stated that sport today is losing its traditional role and autonomy (Rogge, 2010). As a prerequisite for the autonomy of sport, some authors such as Idroten believe that sport should have its own independent judiciary system based on the principles of democracy (Idrotten, 2005). Serdyukov draws attention to the fact that the autonomy of sport is also related to the existence of specialized agents acting in resolving disputes in this area, which are so-called "special competence" (Serdiukov, 2010). This is also the work of Ponkina titled "Autonomy of Sport" (Ponkina, 2013).

Margulis (2005) argues that the issue of autonomy has also been linked to the fact that sports courts imposing disciplinary sanctions or ruling on disputes are final or can be contested in a Court of common jurisdiction. Sports courts can be heard by arbitrators sport and by a court of general jurisdiction.

Some sports developing primarily amateur sports must be protected with rules that encourage visits to their competitions and events. For example, their sports calendars have to be arranged with television programmes so that competitions will be broadcasted instead of other TV and radio programmes in order to attract attention of spectators and listeners and promote the sport.

The World Football Association (FIFA) has put into use a website where players, judges and club officials can report suspicions of match fixing.

FIFA has announced that all such suspicions can be reported to bkms-system.net/FIFA and the information will be directly accessed by the Ethics Committee investigator Michel Garcia. The site is already active. This is part of the Black Lot's new strategy. On bkms-system.net, anyone can write a suspicious match letter [https://www.blitz.bg/sport/svetoven-futbol].

As necessary measures, changes can be made to the rules governing the training of athletes in the country. To allow all sports to develop it should be used all sports facilities and thus contribute to the development of youth and sport so that sports clubs play an important role in cities and villages and thus improve and encourage the training of young players and increase the development of sports. This development should also be linked to strict control effectuated by sports organizations.

We have to examine again the legal nature of autonomy in sport and as its basic prerequisites we can distinguish: the specific structure of sport; own standards based on the principle of Fair Play; an effective principle of dialogue between public authorities and non-governmental organizations developing sport; (an enhanced role for non-governmental organizations and special investigative bodies, such as the specialized criminal court, for example); prevention of deviant behavior.

Respecting the autonomy of sport means achieveing its goal when the relevant rules are constantly and voluntarily observed (Gambelunghe, 2005).

We support Zahari Zahariev's (2015, pp. 16) view that relationships in sport are not explicitly regulated as the basic right of the citizen (as, for example, the labor right or the right for personal correspondence and others). As text we have some regulation in primary public acts in the Constitution Art. 52 paragraph 3, obliges the State to promote sport (chapter "Basic rights and obligations of citizens") (Konstitucia na Republika Bulgaria).

The encouragement of sport led to a coming light in a tunnel from a counter-incoming train. It is precisely the absence of obligation concerning the State's support the reason that led to this situation where the State from a promoter have to become a manager with corresponding responsibilities which is one of the reasons for the current state. Well not exactly the reference field covered part of the sport brought to light in the tunnel of a counter coming train, on the one hand it has the other simulates the activity

On the other hand, sport law is positioned as a sub-sector of civil law, and the basic principle that is applied in it is the principle of equality - the dispositive principle, which is directly related to autonomy of sports organizations (Zahariev, 2016; Povil, 1999; Zahariev, 2015).

Such solution is also found in the Gaetano Dona case against Mario Mantero. Subject to Articles 7, 48 and 59 of the EEC Treaty, in the operative part of its judgment the court refers to rules or national practice, even if adopted by a sports organization restricting the right to participate in football matches as professional or semi-professional players only for nationals of the Member State in question are incompatible with Article 7 [http://eur-lex.europa.eu].

The Bosmon judgment states: 'The immediate effect of Article 48 of the EEC Treaty can not be relied on in support of claims for transfer, training or development benefit which have already been paid at the date of the present judgment; is still due under an obligation that arose prior to that date, with the exception of entities who before that date brought an action or made an equivalent claim under the applicable national law" [http://curia.europa.eu]. Changes the legislation in Europe subsequently to this and the governors of the FIFA and the head and subsequently applies also in Bulgaria.

The limits of autonomy in sport do not mean total independence and complete freedom without rules (Latty, 2007).

Those of the broadcasters so that during their competitions they will not broadcast any other on television and radio to attract visits and popularize the sport. Reasons for the current state. On the other hand, sport law is positioned as a sub-sector of civil law and the basic principle that is applied in it is the principle of equality, the principle of the dispositive principle, which has a direct bearing on the autonomy of sports organizations.

According to the Greek Vice-Minister of Culture and Sports, Yiannis Ioannides, shared at the 11th "Council of Europe" Conference (Athens, Greece, 11-12.12.2008), "we have to give answers to the main questions in order to define the limits of the autonomy of sport, as well as to determine the cases in which the state has to intervene" [http://eur-lex.europa.eu].

CONCLUSION

As a result of the study of legal and sociological literature on the autonomy of sport, the hypotheses raised are generally confirmed.

Transition societies are characterized by the disintegration of the old regulatory system and, at the same time, the instability of the new regulatory system and its corresponding institutions. In such a situation there is a crisis in social integration. People follow a "new" morality, their values and motives are different.

Willingness, which is characteristic of the large part of the norms, should be replaced with clear rights, obligations and responsibilities. The current law on sport largely fails to meet today's demands for sport.

A complex and interdisciplinary approach is needed to identify and overcome deviant behavior in sport at different levels, as well as strengthened formal and informal control by State and non-governmental organizations working in this field.

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INTERNSHIP AND EMPLOYMENT IN HEALTH-RELATED PHYSICAL ACTIVITY SECTOR: CURRENT SITUATION IN SERBIA

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SUMMARY

Tempus SPEED project created ground breaking idea in 2013, which was supported by the European Network of Sport Education (ENSE): to address the need of new sectorial qualifications in the strategic fields of health-related physical education & physical activity, wellness, leisure & tourism, sport management, social work, by developing a joint model of vocationally oriented Master with diverse learning outcomes & competencies to provide a better match between job market needs and the qualifications offered. Three years after hard curriculum development and consultancy with SPEED Consortium members from the Western Balkan and EU countries, Joint Models of Master of Science in Sport Professions were accredited in Serbia: Physical Activity, Health and Exercise Therapy (PAHET), by the University of Belgrade and Physical Education, Physical Activity and Health (PEPAH), by the University of Niš and the University of Novi Sad.

Keywords: New competences, sport professions, job market, stakeholders, Universities, students,

THEORETICAL CONSIDERATIONS OF THE PROBLEM

Promoting sport events and a sustainable tourism & wellness industry is a priority in the development plans of the Western Balkan (WB) countries, while sport is also a recognized tool in promoting health & socioeconomic development, contributing to universal education, social inclusion, prevention & reduction of violence, gender equality, and environmental sustainability. Motivated, expert sport professionals are needed, able to address these diverse needs and foster a transfer of skills into everyday life situations (Caporossi & Tschan, 2017).

Research on the changes and relationship between the Higher Education in Sport and employability in Serbia had been initiated in 2013 by Tempus SPEED project, funded by the European Commission and supported by the European Network of Sport Education (ENSE). Within the last decade, ENSE developed into a major European organisation by representing a reliable partner for discussions at European level, enabling new topics in relation to sport education and training to be discussed, analyzed and evaluated.

Hence, Tempus SPEED project created ground breaking project idea in 2013, which was supported by ENSE: to address the need of new sectorial qualifications in the strategic fields of health-related physical education & physical activity, wellness, leisure & tourism, sport management, social work, by developing a joint model of vocationally oriented Master with diverse learning outcomes & competencies to provide a better match between job market needs and the qualifications offered, while fostering partnership between universities and stakeholders, and practical training in real working environment (Caporossi & Tschan, 2017).

Three years after hard curriculum development and consultancy with SPEED Consortium members from WB and EU countries, Joint Models of Master of Science in Sport Professions were accredited in Serbia: Physical Activity, Health and Exercise Therapy (PAHET), by the University of Belgrade and Physical Education, Physical Activity and Health (PEPAH), by the University of Niš and the University of Novi Sad. Upon accreditation, teaching and work placements, two generations of students finished their academic obligations and obtained master diplomas.

Joint Models of Master of Science in Sport Professions in Serbia are designed to be vocationally oriented: student workload expressed in hours through internship and practice, range from 480 for the University of Novi Sad, to 589 for the University of Niš, and 633 for the University of Belgrade.

By emphasizing the necessity of the internship, the Faculty of Sport and Physical Education of Niš, the Faculty of Sport and Physical Education of Novi Sad and the Faculty of Medicine of Belgrade signed, as direct implementers of master studies ahead of their Universities, several Cooperation Agreements. For instance, with the Health Centre Niš, the Clinical Centre Belgrade, the Clinical Center of Vojvodina, the Special Rehabilitation Hospital Ribarska Banja, and the latest with the Special Hospital Čigota (last two listed are situated in two well known spa centers in Serbia), enabling the young experts to have the best professional practice training, as well as a chance to get employment in the Physical Education, Physical Activity and Health sector, in accordance with the job market needs. The intention is to retain the best and the high-quality students in Serbia and to make them future cornerstones of the Serbian progress and professional development in health-related physical activity.

Internships within Joint Models of Master of Science in Sport Professions in Serbia are used to share global strategy and mission of the World Health Organization (WHO), i.e. to stress problems of nutrition, physical activity and health, and to promote physical activity as the disease prevention strategy.

Although childhood obesity brings a number of additional problems in its train (hyperinsulinaemia, poor glucose tolerance and a raised risk of type 2 diabetes, hypertension, sleep apnoea, social exclusion and depression), the greatest health problems are seen in the next generation of adults as the present childhood obesity epidemic passes through to adulthood (Lobstein, Baur, & Uauy, 2004). Obesity is associated with and contributes to a shortened life span, type 2 diabetes mellitus, cardiovascular disease, some cancers, kidney disease, obstructive sleep apnea, gout, osteoarthritis, and hepatobiliary disease, among others. Weight loss reduces all of these diseases in a dose-related manner—the more weight lost, the better the outcome (Bray et al., 2018).

Sedentary youngsters should progress toward the recommended level of physical activity gradually (Tremblay et al., 2011). The same goes for the sedentary adults and elderly subjects.

According to available global data of WHO (n.d.), related to 2010, 23% of adults aged 18+ years were insufficiently active (men 20% and women 27%). Overall, older adults were less active than younger adults: 19% of the youngest age group did not meet the recommended level of physical activity (one hour or more of at least moderate intensity on five or more days a week), compared to 55% of the oldest age group. However, young women were slightly less active than middle-aged women. Compared to their inactive peers, children and adolescents doing at least 60 minutes of moderate- to vigorous-intensity physical activity daily have higher levels of cardiorespiratory fitness, muscular endurance and strength. Documented health benefits of regular physical activity among young people also include reduced body fat, more favorable cardiovascular and metabolic disease risk profiles, enhanced bone health, and reduced symptoms of anxiety and depression.

By respecting those recommendations, students and staff at the Special Hospital Čigota that are working through internship with excessively overweight patients (many of them exceed 150 kg of body mass), achieve great results: by changing health behaviors, by limiting daily calorie intake to 1200 KCal, and by regular exercising with the intensity of 60% of the maximum heart rate, patients experience weight loss of at least 4 kg per month.

During the internship, each student is guided by the authorized person in charge (mentor). Student' stay is documented by the Internship Report, within their Internship Diary, where he collects diverse data, different observations, identifies and analyzes problems and data, gives a critical overview of the situation, and proposes measures for possible changes and improvements.

CONCLUSION

So far, the acquisition of new competences and the positive achievements in health-related physical education & physical activity, wellness, leisure & tourism, recommended students of the Master of Science in Sport Professions to employers, not only in Serbia, but also in Scandinavia, United Arab Emirates and United States of America. The question remains: should they have been educated to live or stay in Serbia?

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CHARACTERISTIC FEATURES OF SPORTS WRITING

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SUMMARY

When students switch to the university level demands they are presupposed to have sufficient knowledge to investigate sports language elements such as the structures, patterns, mental representations, and processes that underlie written and spoken languages. Spoken because students have to prepare oral presentations of the curricula units, and written because they start writing seminar papers from their freshmen year and continue doing so up to the doctoral level of studies. Sports language architecture was researched in Serbia and offers the following findings: textual language markers in the introductory, methods, and conclusion sections of sports literature are represented by 96.67%, 95.13, 97.43% respectively, language action signaling markers with 0.26%, 0.08%, 0.07% and 0.14% respectively, interpersonal language markers with 2.97%, 4.79%, 3.39% respectively, and authors categorical assertion with 0.10%, 0.00%, 0.07 and 0.06% respectively. In a sports literature corpus of almost 320.000 words (scientific papers), and a sub corpus of 800.000 words (sport related books), 11.835 different type markers or language units were found. To help our students learn how to write in a foreign or second language, and thus prepare them for a volatile labor market in the sports arena, we as teachers have to improve the comprehension and production of sports language in their textbooks, tutoring sessions, classrooms, and computer-based training.

Keywords: sports language, rhetoric, processing, writing, publishing

INTRODUCTION

When trying to comprehend any discourse there are five levels of cognitive representation. These are surface code, text base, situation model, pragmatic communication, and discourse genre.

The surface code is a record of the exact wording and syntax of the sentences. It stays in the short-term memory which means that it is preserved in memory for only a few seconds when technical text is read. The text base, on the contrary, contains explicit propositions in the text in a stripped-down form capturing just the semantic meaning but losing details of the surface code.

The situation model (or the mental model) is the referential mental world of what the text is about. The construction of an adequate situation model requires a sufficient amount of relevant world knowledge, such as general knowledge, for example, about sports and mechanical props and sport specific equipment, when considering sports sciences. Deep comprehension consists of the construction of this referential situation model, whereas shallow comprehension is limited to the surface code and text base. The situation model, for example, a biomechanical explanation of a shotput, is retained in the memory much longer than the text base and the surface code, which are meant to give a detailed presentation of the whole sporting event and the particular model of a shotput trajectory, assuming that the comprehender, in our case a PE student, has adequate world and of course, sports knowledge to build a particular situation model.

The pragmatic communication level refers to the information exchange between speech participants. This means that both teachers and students can establish pertinent communication about athletics events -namely the shotput discipline. In a two-party oral conversation, the two speech participants take turns speaking while pursuing conversational goals. The teacher's goal is to explain the content of the teaching unit and the student's goal is to grasp at least the mental model meaning that is conveyed through linguistic signals. There may be additional participants in a conversation, such as side participants, for example other students engaged in a practical demonstration of a shotput action, or in-step kick, in the circle of conversation, and bystanders who are outside of the circle, but must be alert to the ongoing teaching process because they might be asked to repeat the whole process.

Discourse genre is the type of discourse - such as narration (stories), exposition, persuasion. There are different discourse classification schemes organized in a multilevel hierarchical taxonomy. Deep comprehenders construct rich representations in the situation model, and later on visually or auditorily remember those models. Pragmatic communication and discourse genre are also important to them, whereas the text base and surface code have a secondary status. Thus, if we want to promote deep comprehension we must design questions that emphasize the situation model, inferences and reasoning.

Discourse Coherence

Coherence is achieved both within and between the levels of representation when comprehension occurs. Thus in order to connect the phases of a sporting event and trace its performance the student needs to logically follow the steps in the text, starting from an example as in

- The kinetic chain: a push-like or throw-like motion
- Optimum angle/height of release
- Speed dynamics
- Throwing technique: Gliding or rotational.

Thus the text must have an introduction:

"To execute successful movement in shot put the individual needs to have a solid stable base of support".

There follows the course of action and all consecutive steps to finish the routine.

"The individual rotates their torso and their back knee is bent."

The techniques must be explained thoroughly.

"The shot put is placed into the open kinetic chain movement category because the individual is able to move their hand freely when pushing the shot, however, their shoulder movement is constricted due to it being attached to the body."

METHODS

Our research study was focused on rhetorical functions and metadiscourse in sports scientific literature. The corpus comprised 60 scientific papers in bio-physiology of sport, sports psychology and sociology, published in the period 2000 -2007, in highly referred journals such as: *Cell* (C), *Molecular Cell* (MC), *Molecular and Cellular Biology* (MCB), *Journal of Biological Chemistry* (JBC), *Molecular Biology of the Cell* (MBC), *Journal of Sports Psychology, Sports medicine, Sociology of Sport*. Thus a corpus of 320 000 words was gathered. We also included books such as Houlihan, B. (2002). *Dying to win – Doping in sport and the development of anti-doping policy*. Council of Europe Publishing, *UK Presidency of the EU, Independent Sport Review* (2005). Report by Jose Lous Arnaut, Hay, G. J. (2005). *The Biomechanics of Sports Techniques*. Prentice Hall, Inc., Englewood Cliffs, N.J., Stephan Wassong (2004). Pierre de Coubertin *American Studies and Their Importance for the Analysis of His Early Educational Campaign*. This sub corpus gave us another 800 000 words.

RESULTS

We also made a clear-cut division of the rhetorical units defining a scientific paper such as the Introduction, Method, Discussion and Conclusion following Swales' genre analysis theory. Each performance of a genre, in our case sports genre, demonstrates its degree of proto-typicality, disciplinary membership, historical moment, authorial identity, and other qualities shared with other members of any given discourse community. Thus through researching signposts in sports text we have found that sports writers also follow some prescribed norms and canons. These are tightly connected with the Anglophone norms of writing. However, cultural norms and idiosyncrasies do shape the writing process, and sport is not an exception. To exemplify it we cite the example of sports psychology paper architecture.

To provide clarity, we present a Table of markers found in the whole researched scientific sports literature texts corpus (scientific papers and books).

Table 1 Markers in the whole texts corpus

MARKERS IN THE WHOLE TEXT CORPUS								
	Introduction		Method & Discussion		Conclusion		Whole text	
	no.	%	no.	%	no.	%	no.	%
Markers of textual connection	3742	96.67	3730	95.13	3939	97.43	1141	96.42
Markers to signal discourse actions & authors reference to discourse	10	0.26	3	0.08	3	0.07	16	0.14
Analysis of the interpersonal metadiscourse	115	2.97	188	4.79	98	2.42	401	3.39
Markers of the authors categorical assertion	4	0.10	0	0.00	3	0.07	7	0.06
Total markers	3871	100.0	3921	100.	4043	100.0	1183	100.0

Swales' influence on genre studies stretches outside of applied linguistics because the concepts he establishes are powerful and widely applicable to genre theory and teaching alike. If we want to translate the obtained findings of this study, we have to create such teaching materials to guide our PE students through the wealth of sports writing norms and specificities. Swales' concepts are also highly rhetorical, involving such classically rhetorical concepts as purpose, audience, and means.

Many in genre studies, including those following the work of Swales, have developed rich, grounded, and elaborated pedagogies to improve students' genre competence. What is still required, though, is instruction in genre performances, the ways that abstracted genre competence plays out in actual texts, including ones the students will write during their studies. A time-honored way of addressing performance is experiential: having students write, read out their paragraphs, offer feedback, and having students reflect and revise after discussion with their classmates. That instruction, too, is helpful, necessary, and valuable. To go back to the research data we just want to draw the attention to the wealth of metadiscourse markers found in sports literature, although lots of scientist claim that sports discourse does not differ from other social sciences writing norms.

Table 2 Markers of textual connection

MARKERS OF TEXTUAL CONNECTION								
	Introduction		Method & disc		Conclusion		Whole text	
	no.	%	no.	%	no.	%	no.	%
Markers of textual connection to express logical relations meaning equal relations	51	1.36	28	0.75	54	1.37	133	1.17
Markers of expanding	2808	75.04	2927	78.47	2612	66.31	8347	73.15
Markers of explaining	138	3.69	121	3.24	157	3.99	416	3.65
Markers of causal relations	67	1.79	57	1.53	183	4.65	307	2.69
Markers of contrasting	210	5.61	241	6.46	313	7.95	764	6.70
Markers of concession	58	1.55	79	2.12	46	1.17	183	1.60
Markers of conclusion drawing	3	0.08	7	0.19	5	0.13	15	0.13
Markers of temporal-spatial relations	14	0.37	18	0.48	13	0.33	45	0.39
Markers of sequence signaling for propositional content	94	2.51	140	3.75	222	5.64	456	4.00
Markers of reminding to the given propositional content	299	7.99	104	2.79	326	8.28	729	6.39
Markers of signaling method of introducing propositional content	0	0.00	0	0.00	0	0.00	0	0.00
Markers of topic emphasizing	0	0.00	5	0.13	3	0.08	8	0.07
Markers of reformulating propositional content	0	0.00	3	0.08	5	0.13	8	0.07
Markers of textual connection - total	3742	100.0	3730	100.0	3939	100.0	1141	100.0

DISCUSSION

There are some methods of improving deep comprehension and learning by tapping discourse processing mechanisms, including: (1) constructing explanations, (2) asking questions, (3) challenging a learner's beliefs and knowledge, and (4) tutoring.

Constructing explanations. Good comprehenders generate explanations as they read a text or listen to lectures. These explanations trace the causes and consequences of events, the plans and goals of agents and the logical derivations of assertions. The questions that drive explanations are why, how, what-if, and what-if-not questions. For example, a deep comprehender might implicitly ask the following questions while reading the Shotput technique text: How does speed dynamics influence the distance the shot will carry? Does the shot put follow a throw-like or push-like movement pattern? What is the optimum angle of release and release height? How does this influence the distance that the shot will carry? Is a rotational shot put technique more beneficial than a gliding technique? Students learn much more when they construct these explanations on their own than when they merely read or listen to explanations.

Asking questions. Students should be encouraged to ask and answer deep-reasoning questions to help them construct explanations. Unfortunately, students are not in the habit of asking many questions. A typical student asks only 11 questions per hour in a classroom, and less than 10 percent of student questions involve deep reasoning. When students are trained how to ask good questions while reading or listening to lectures, their comprehension scores increase on objective tests.

Probing the learner's biased beliefs, knowledge and stereotypes. One of the easiest ways to get students to ask questions is to challenge one of their biased beliefs, and thereby put them in cognitive disequilibrium. For example, if a teacher expresses the claim that boxing is a bloody sport which should be banned altogether, a large number of students will question such a claim try to give counterarguments. Research on question asking has revealed that genuine information-seeking questions are inspired by contradictions, anomalies, incompatibilities, obstacles to goals, salient contrasts, uncertainty, and obvious gaps in knowledge.

Signposting in academic writing

Academic writing should be easy to follow. One way to do this is to give your reader clear signposts about how your argument is developing. Here are some examples of effective signposting.

1. Signposts to introduce something new

One aspect which illustrates … can be identified as …

The current debate about … illustrates/identifies/highlights …

With regard to…/ with respect to…

Initially/secondly/finally, …

2. Continuing an argument with a related point

Furthermore …

To further understand the role of …

In addition …

Similarly …

Likewise …

What is more …

3. Going into more detail on a point/rephrasing

In particular …

Specifically …

Concentrating on …

By focusing on … in more detail, it is possible to …

To be more precise …

4. Linking to a different point

Having established …, it is possible to consider …

… is one key issue; another of equal/
similar importance/significance is …

Also of importance is the issue of …

5. Reintroducing a topic

As discussed/explained earlier, …

The earlier discussion on … can be developed further here, …

As stated previously, …

As noted above, …

6. Introducing an opposing/alternative view

However, …

Conversely, …

In contrast, …

Alternatively, …

Nevertheless/Nonetheless, …

7. Reasoning/summarizing the point

Consequently/As a consequence, …

Accordingly, …

Therefore, …

It could be concluded that …

The strength of such an approach is that …

For this reason …

CONCLUSION

To sum up, research in discourse processing can help solve some of the pressing challenges in education. Discourse plays an important role in helping the learner shift from shallow to deep comprehension, and from being a fact collector to being an inquisitive explainer. But to make our students proficient in text handling is a huge task.

To accomplish all these we need tools and the right tools for the students to freely explore the wealth of sports writing are small words called metadiscourse markers, knowledge of their functions, their proper meaning, their well deserved place within the framework of foreign or second language writing pedagogy.

The differences in what genres students choose to write, given a choice, may derive from their past experiences with a genre and their prior genre knowledge, an element of genre competence. To build that competence into better genre performance teachers might apply what research on transfer suggests: emphasize strategies within a genre and assign frequent reflection in order to develop students' metacognitive awareness.

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ABUSE OF DOPING SUBSTANCES - KNOWLEDGE AND ATTITUDES OF THE REGISTERED NIŠ SPORTS CLUBS ATHLETES

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SUMMARY

The use of doping substances is a serious social issue, not just a sporting issue. The importance of these substances abuse issue is reflected in a high frequency and harmful consequences of their long-term use, especially in young people. This research can be significant because of the population that is involved in the research, since very often professional athletes are role models of adolescents and young people, who often mimic them, including drug abuse as well. A survey was conducted on a sample of subjects - registered athletes of sports clubs in Nis. 80 registered athletes from various sports in Nis were surveyed. The obtained results can be accepted as a certain indicator of information, perception, knowledge and attitudes of Nis sports clubs athletes about the increasing problem of modern sports today, and can be relevant for a wider social community.

Keywords: Doping, sport, abuse

INTRODUCTION

Today, great attention is paid to the illicit recovery stimulus substances, however, in our area, recent research studies on the application of recovery stimulus substances have scarcely been published (on a satisfactory sample of subjects and applying correct methodological procedures), and for these reasons, only studies mainly related to the attitudes of athletes regarding the training process (which is in the function of the system of preparation) and training or some other means of recovery, can be used (Smajić et al. 2009, 2009a, 2009b and 2010).

Information on doping athletes was recorded at the Olympic Games (OI) in St. Louis (1904) when the marathon winner was administered several subcutaneous injections of strihnin sulphate while on medical care (Pupiš, & Polgar, 2006). First death due to the use of unauthorized substances was recorded in 1896 when the English biker Artur Linton passed away during the Paris-Bordeaux race after the administration of ephedrine (Pupiš, & Korčok, 2004).

In the 1960s, a dramatic increase in the use of doping in sports, which ended with a fatal outcome, was observed (Mandarić, & Delibašić 2014). In the XVIII OG in Rome, in 1960, a Danish cyclist Kurt Enamas Jansen died, who, according to experts, took strong doses of amphetamine and nicotinic acid derivatives from his coach. After this event, a Medical Commission of the International Olympic Committee (IOC) prepared a professional analysis and material accepted at the Olympic Games in Tokyo in 1964, containing first definition of doping, and in 1975 the IOC banned the use of all forms of stimulants (Pavlović, Savić, Tošić 2015).

The use and abuse of various substances is regularly recorded in all professions where success depends on physical abilities and performance (Sekulić et al., 2008).

Undergoing various pressures, ranging from self-expression to the influence of parents, coches and the wider community aiming at fame and money making, athletes are often tempted to use prohibited means to improve results. In order to continue with competitions an athlete must quickly restore the energy consumed and restore the body to a functional state as well. To this means special substances are used which can be classified into two categories: allowed ones and unauthorized ones. Every athlete who devotes most of his time to sport sooner or later faces the question of "to be or not to be", i.e. to reach for the unauthorized substances or not. This question is above all of the moral-ethical nature (Ranđelović, N., & Živanović, N. 2008).

The use of prohibited substances is in contrast to the physical and mental integrity of athletes and sports ethics. A more familiar name for the use of illicit substances is doping, which is one of the biggest problems in sports (Erceg, & Fattorini, 2011).

Particularly worrying is the fact that doping today is widespread not only among top and non-professional athletes, but also among people, mostly young people, who practice sports only recreationally. Research shows that around fifteen million people use doping, most of them anabolic steroids, suggesting that regulations prohibiting the use of doping by professional athletes are not enough to protect health as more and more recreational athletes use these substances (Pajčić, & Sokanović, 2010).

Radovanović, Jovanović, and Ranković (1998) point to the expansion of the use of illicit substances and methods, by non-professional athletes too, stating the necessity of preventive work and the reduction in the frequency of doping use in this very numerous category of athletes.

The use of doping substances is a serious social issue, not just a sporting issue. The importance of the problem of abuse of these substances is reflected in the high frequency and harmful consequences of their long-term use, especially in young people.

The word "doping" appeared for the first time in the English vocabulary (1889), denoting a certain mixture of opium and narcotics (Müller, 1993) and over time a term doping was accepted in sports, and in most general terms it represents the use of prohibited substances or methods in order to improve sports results (Deligiannis et al., 2006). The doping definition of the International Olympic Committee reads: "Doping refers to the use, taking and giving to the human organism of foreign substances or to the large amounts of substances normally contained in the body, with the aim of artificially stimulating or enhancing the athletic competence of athletes, which is contrary to sports ethics as well as the physical and mental integrity of athletes. " (Živanović, N., Ranđelović, N., Stanković, V., & Pavlović, P. 2010.)

Doping represents the use of physical and chemical agents that increase the effect, i.e. these are substances that increase the efficiency of training and competition. In doing so, a number of athletes want to win at any price and do not think of harmful effects, nor sports ethics. However, there is also a negative side of doping, where many athletes have had health problems, and some of them have even lost their lives. In addition, doping gives athletes an advantage over others which is not ethical nor fair. That is why there have been initiatives to expel doping from sports. Initially, the task was taken over by sports organizations, which excluded athletes who competed under the influence of prohibited substances. Later, some states and non-governmental organizations, primarily in Europe, joined the struggle. After 1998, in all anti-doping organizations, it became evident that a common fight against doping and the adoption of the uniform rules were needed. To this purpose, the World Anti-Doping Agency (WADA) was established, which should administer anti-doping policy throughout the world and which should include sport organizations, private individuals and state institutions in the fight against doping.

Despite all the repressive measures taken in doping controls and the adoption of anti-doping laws, people fighting doping are aware that it is very important to prevent the use of doping by educating and informing wider community about its adverse effects.

There are a number of studies dealing with the abuse of doping substances topic.

Ranđelović, Savić, Pantelić, Živković, Rajić, (2016) conducted a survey on this topic on a sample of 100 high school students in Niš. Smajić, Tomić and Bekvalac (2011) in a research called - The views of different age players of non-allowed stimulating substances have come to the conclusion that they do not differ from one another and are unique in confirming the proposed attitudes. Pavlović, Savić, Tošić (2015) studied the perception, attitudes and knowledge of the secondary school students about the use of the unauthorized stimulants in sports. Relevant results have been obtained which are a global indicator of the knowledge and attitudes of the secondary school students about the growing problem of today's modern sport called doping. The subject of research by some authors (Laure, Bisinger, & Lecerf, 2003) included knowledge and attitudes of the student population on the problem of doping in sports. Melia et al. (Melia, Pipe, & Greenberg, 1996) conducted a survey in five Canadian regions that included 107 schools with the aim of determining the prevalence of the use of anabolic-androgenic steroids, their attitudes and knowledge of doping. Kindlund et al. (Kindlundh, Isacson, Berglund, & Nyberg, 1998) conducted a survey among adolescents of the Uppsala High School to determine the level of illegal drugs use in sports. Studies of the anabolic androgenic steroids (AAS) use in a random sample from five gyms were conducted by Kanayama et al. (Kanayama, Gruber, Pope, Borowiecki & Hudson, 2001).

The prevalence of the use of AAS in the Serbian population was studied by some domestic researchers (Jovanović & Radovanović, 2001). Vanjek et al. (Wanjek, Rosendahl, Strauss, & Gabriel, 2007) published the results of a survey conducted in 2004 in Thuringia (Germany) based on a survey in several primary, secondary and vocational schools. The findings indicate that there is a need to improve specific knowledge about doping among pupils and students and that their attitude towards doping must be changed. Pavlović and Pupiš (2013) studied this topic on the population of 50 students of physical education and sport of East Sarajevo, and also Pavlović and Idrizović (Pavlovic, & Idrizovic, 2013) investigated this topic on a joint sample of 100 students of physical education and sport of East Sarajevo and Niksic. Mandarić and Delibašić (2014) in their research Sanctioning doping in sports suggest that sport at a top level imposes new and increasingly demanding physical and psychological pressures, and the desire for competition, victory and self-expression brings athletes into temptation to use prohibited substances for achieving the best results. Mitić and Radovanović (2014) in their research indicate that the use of anabolic-androgenic steroids is an important social issue, not just a sports problem. The importance of the problem of the abuse of these substances is seen in a high frequency (especially in young people) and with serious harmful effects of their long-term use.

METHODS

The subject of the study was the abuse of doping substances in sport, and the main goal was to find new knowledge about the perception of the considered phenomenon in a certain group of subjects.

In accordance with the nature of the problem and the aim of the research, the method of systematic and non-experimental research has been applied. The method of qualitative analysis of the content of documents was also used as one of the basic methods in social sciences. An analysis of the contents of various written sources was carried out, containing facts relevant to this topic.

Subjects

Survey research is the second part of the research. The survey was conducted on a sample of subjects - registered athletes of sports clubs in Nis. 80 registered athletes from various sports in Nis were surveyed (24 were female and 56 male). Subjects sports engaged are: football, basketball, volleyball, judo, gymnastics, karate, swimming, and handball. The average length of the sport experience is 12 years.

Procedure

In this survey, the measurement of the level of information of registered athletes on the abuse of doping substances was done using a questionnaire-survey. For the purposes of this research, a survey was conducted by the professional staff at the Faculty of Sport and Physical Education in Nis. The questionnaire was composed of 16 clearly defined questions related to certain qualitative knowledge and attitudes on the use of doping substances in sport (7 questions on doping issues and 9 questions on doping attitudes). Participation in the research was on a voluntary basis, and the interview was anonymous. Before the survey, subjects were informed about the purpose of the research and were indicated that data from personal testing would not be abused. The time for completing the questionnaire was unlimited.

Statistical analysis

The research was carried out through a questionnaire, which was made up of a group of questions aimed at checking the knowledge on doping subjects and a group of questions aimed at checking the attitudes and opinions of the subjects about the (ab) use of doping. In some issues that tested the attitudes of the subjects with the offered answers, the opportunity was given to give comments where the subjects explained the stated attitude. These issues were aimed at closer inspection - an explanation for the views expressed. For these questions, the systematization of the response was done in order to get rid of the common elements on the basis of which it was possible to make the appropriate conclusions. Descriptive statistical analysis was applied to questions where it was possible to select only one of the offered answers. The results are expressed in nominal and percentage values.

RESULTS

The questionnaire was composed of the two sets of questions. The first group of questions was aimed at determining the knowledge of the subjects about doping. The second group of questions was aimed at determining the attitudes and opinions of the subjects regarding doping and its use.

Question - Do you know what doping is was meant to determine the subjective feeling of the subjects about the knowledge of the concept of doping. The majority of subjects (89%) answered that they knew what doping was, while (11%) answered that they did not. However, where they needed to write what doping is in their own words 83% of subjects failed to give a satisfactory definition of doping, although it can be concluded from their answers that they have an adequate idea of what doping is and for what purpose it is used.

In the next item, it was necessary for subjects to list some of the doping groups to which they were assigned. Only 33% of subjects answered this question, with 50% of this number listed only one category and no more than four categories, with many wrong answers to this question.

In the question where individual doping substances were supposed to be listed, the answer was given by 50% of the subjects. Out of this number, 52% listed only one substance, and only two subjects listed four substances. Subjects were most often referring to ephedrine, derinol, tribestan, cocaine, marijuana, ecstasy, blood doping, testosterone, estrogen.

When asked which factors influenced the use of doping, the majority of subjects thougt that the factors influencing the use of doping were: greater efficiency of achieving results with the help of the applied means or method, high competitive standards, dissatisfaction with their own effect, lack of confidence, rewards and recognitions, influence of the coaches and doctors, the structure and type of the personality.

The question concerning the abbreviation of the World Anti-Doping Association was answered by 33 subjects. The correct answer was given by 29, and 47 subjects did not give any answer or they stated that they did not know it.

Asked to refer to an athlete who they knew were found to have used doping substances, 66 subjects answered. The largest number of subjects (22) referred to Nikola Radjen, 18 subjects to Lance Armstrong, 16 subjects stated Victor Troicki, 4 subjects mentioned Justin Getlin and Michael Felps, 3 Tyson Gay, 2 Lamara Odom, Ljubiša Jocić and Maradona, and one subject mentioned Ben Johnson, Merion Jones, Lepomir Bakić, Carl Luis, Janko Tipsarević, Hristina Stojadinović. The largest number of subjects indicated Nikola Rađen, Viktor Troicki and Lens Armstrong, probably because their cases were mostly covered by the domestic media at the time of the survey.

Most subjects (80%) do not support the use of doping drugs, which is expected, and (6%) of subjects support the use of doping. The other (14%) of the subjects had no opinion on this issue or did not want to give answer.

When asked if the use of doping means abuse of sports and is not acceptable even if the goal is achieving the highest results and recognition following was obtained: most subjects (76%) fully agree that the use of doping means abuse of sports and is not acceptable, even if the goal is to achieve the highest sports results and recognition, 8% partially agrees, 9% have no opinion, but there are also a number of subjects (7%) who completely disagree with this claim. When asked to clarify the previous position, most subjects think that the use of doping substances is not acceptable for ethical, moral, health reasons and due to the creation of inequity among the contestants.

The majority (71%) of subjects disagree fully with the claim that achieving significant sports results is not possible without the use of doping substances, a number of subjects (11%) partially disagree with this claim, 9% do not have a viewpoint on this, 5% partially agrees, but there are also 4% of those who fully agree with this claim. In the explanation of this attitude, the majority of subjects state that the achievement of significant sports results is possible without the use of doping substances, with great renunciation, worthwhile work, hard work, perseverance, strong will, proper nutrition and psychic preparation. Some have also mentioned well-known athletes (Novak Djoković, Jusein Bolt) as an example of achieving top sports results without the use of doping agents.

When claiming that doping substances are used by most professional and top registered athletes who can afford them because of their financial opportunities, 39% of subjects disagree completely with this statement, (10%) subjects partially disagree, (32%) of subjects have no opinion on it. There are also those who partly agree with this statement (13%). Only 6% of subjects agree with this view. When explaining the answers to this question, the opinion of the subjects was divided. There are more people who think that money is not a decisive factor in whether someone will use doping substances, but that depends on the character of the athlete himself, while some of them think that doping substances are used by athletes who can afford them because of their financial opportunities.

About the fact that the use of doping substances today is impossible to get rid of and remove it from registered sports, opinions are divided. Most of the subjects (30%) do not fully agree with this position, the same number partially agree and partially disagree (15%), fully agree (16%), and do not have a stance or simply do not know whether it is possible or impossible to deal with it (24%). In explaining the answer to this question, a part of the subjects think that it is impossible to remove doping substances from sports because it is largely represented, and because a lot of athletes use doping, others think that it is possible to remove it with increased control and stricter penalties for those who use doping substances.

Subjects consider athletes most responsible for the use of doping in sport (72), (31) subjects think that athletes' managers are to blame, (26) subjects think that medical personnel are also responsible, (25) subjects think coaches take responsibility, too.

When questioned about groups of sports most often using doping, the majority of subjects think that doping is most commonly used in athletic sports (74), cyclist sports (24), (18) subjects think that doping agents are most often used in defense or martial art sports.

If there was a certain possibility that the used substance would not be registered and if they would personally use it knowing that it could negatively affect their health, even their life, 70% of the subjects claimed that they would not use it, 23% did not know they would use it, but there are also 7% of those who would opt for it. When elaborating on the answers, the majority state that they would not use doping agents because it would have a negative impact on their health and life and it would be unfair to other competitors. Those who would use doping substances would do so if they had the conditions and resources to achieve their goals or material gains.

DISCUSSION

What is evident is the fact that doping takes on more and more ground in professional and top sport, at various European and world championships, and in the Olympic Games as well. It was expected that the IOC and the International Sports Associations, with education programs, testing, and support for treatment, would manage to reduce illicit substance abuse. However, this did not meet expectations, it is the fact that nowadays more powerful and unrecognizable doping techniques and substances are abused by professional, often top-level athletes, and more sophisticated distribution networks have been developed (Baron, Martin, & Magd, 2007). In addition to the sporting spirit, which is neglected today, regardless of the ranking of the competition, participants are increasingly subject to the use of prohibited stimulants, fraud and deception in order to reach the end goal, while deliberately risking their own lives and future (Pavlović, & Pupiš, 2013).

The main goal of this research was to check the knowledge and determine the attitudes of the athletes of Nis Sports Clubs about the use of prohibited substances in sports. The initial assumption was that this population of the subjects was sufficiently informed and had sufficient knowledge of the problem of doping and all the negative consequences that the use of these substances carries with them. Another assumption was that they generally have a negative attitude towards the use of doping in sports.

The results of this research provided some information about the attitudes and knowledge of athletes of the Niš Sports Clubs about the problem of doping in sports. This research can be significant because of the population that is involved in the research, because very often, professional athletes are role models of adolescents and young people, who often mimic them, including drug abuse (Baron, Martin, & Magd, 2007).

Comparing the results of the current research with the above-mentioned research that dealt with the same problem in similar and somewhat different categories of the population, it can be concluded that these results are to a large extent resembling the results of the previous research studies.

CONCLUSION

Although the research involved a relatively small sample, the results obtained can be extremely important. They can be accepted as a certain indicator of the knowledge, perception, and attitudes of the Nis sports clubs athletes about the growing problem of modern sports today and can be relevant to the wider community.

Based on the results of this research following conclusions can be drawn:

- Based on the questions that were intended to determine the specific knowledge and information of the subjects on doping, it can be concluded that the majority of subjects have basic knowledge and idea of doping.
- Based on subjects' answers, it can be concluded that most subjects do not support the use of doping substances for ethical, moral, health reasons and inequality among contestants, so it can be concluded that the majority of subjects consider doping an abuse of sports and do not approve of its use.
- The answers of the subjects show that the majority believe that the claim that without doping it is not possible to achieve significant results in sport has no justification and that most subjects think that no doping substances are required for achieving significant sports results, but work, effort, persistence and strong will.
- Most subjects would not use doping agents because it would have a bad effect on their health and would be unfair to other competitors, however, it is surprising that there are a number of subjects who would use them if they had the conditions to do so in order to achieve their goals.
- Regarding whether most athletes use doping substances and whether they can be removed from

sports, opinions are divided and a significant number of subjects have no opinion on it.

• When it comes to who is most responsible for the use of doping in sports, it can be seen that in all categories there is a certain number of subjects who have answered and they do not group around one, but are divided into all categories, thus it can be concluded that there is no uniformity and homogeneity of subjects in terms of the responsibility for the use of doping and groups of sports it is most used in.

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INFLUENCE OF MUSCULAR STRENGTH ON MILITARY PHYSICAL TASKS IN THE SERBIAN ARMED FORCES

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SUMMARY

The level of physical ability of professional military personnel (PMP) is checked by applying different tests to assess motor and functional abilities, but there is little research that has confirmed their applicative value. The purpose of this study was to determine the relationship of upper arm muscular strength and explosive strenght with the military readiness obstacle course (MSKILL). The study was conducted on 17 male subjects, 27.71 ± 7 years old, of PMP in the Serbian Armed Forces (SAF). In the research were applied tests for the upper arm muscular strength and explosive strength assignment. Statistica 8.0 was used for data processing. The results have shown a statistically significant relationship between upper arm muscular strength and explosive strength with MSKILL ($R = 0.90$, and 0.810; $R^2 = 0.810$, and 0.610, $p < 0.05$). The upper arm static and repetative muscular strength have an excellent correlation with MSKILL ($r = 0.86$ и 0.84, $p<0.05$). These tests may be the basis for constructing a set of tests to assess military physical tasks.

Keywords: strenght, power, military, soldier readiness, obstacle course

INTRODUCTION

Military personnel on professional and combat tasks often have difficult tasks requiring the presence of streinght, such as recurring lifting, carrying heavy goods over long distances, and realizing a rapid execution of combat maneuvers through combat surroundings (Sharp, Patton, & Vogel, 1998). In most countries in the world, different polygons are constructed to simulate the crossing over the battlefield in order to develop the necessary capabilities to perform the most difficult tasks in military training and to check and monitor the physical capabilities of members of the respective units (Mitchell, Batty, Coyne, DeSimone, & Bensel, 2016). Also, during the realization of such tasks, military personnel is required the carry on the combat equipment witch requires additional strength (Mitchell et al., 2016).

A certain test for military physical ability has been applied in the SAF. MSKILL is designed to simulate crossing the battlefield with diverse obstacles (Ministry of Defence, 2011). Newcomers in the SAF, as well as PMP up to 32 years of age, are expected to justify their physical ability on such a constructed test. Since, due to its complexity, obstacle course is not present in admission for SAF, nor is it included in physical military readiness of PMP older than 32 years of age, it is necessary to further investigate which motor skills and tests relate to MSKILL, construct easy-to-use sets of tests which will be a good predictor in selection, monitoring of the physical ability level and designing of training programs.

In previous research, the tasks of lifing or / and pulling (eg, rescuing victims, overloading with ammunition) are well represented by tests such as different kinds of dragging (Myers, Gebhardt, Crump, & Fleishman, 1984; Rayson, & Holliman, 1995; Carstairs, Ham, Savage, Best, Beck, & Doyle, 2016), hand-grip test (Myers et al, 1984; Rayson et al., 2000), horizontal jumping (Bilzon, Scarpello, Bilzon, & Allsopp, 2002; Harman et al., 2008), and medicine throwing (Cox, 2018).

In order to define the standards for the selection of candidates for admission to the British Army, Rayson et al. (2000) carried out testing using variables of maximal buoyancy, flexed arm hang and pull-ups and determined their high statistical connection with carrying loads. Harman et al. (2008) have come to the conclusion that horizontal and vertical jumps well predict time on the obstacle course, with greater prediction of horizontal jumps because they have a moving forward component. Anaerobic power of the upper and lower extremities have shown good time predictions in the scored time on the obstacle course (Bishop, Fielitz, Crowder, Anderson, Smith, & Derrick, 1999). In the SAF, United States (US) and Australia, military readiness tests include upper arm repetitive tasks. Deakin et al. (2000) found that tests used to estimate repetitive strength and endurance in SAF and the United States (USA) do not have a high significiant correlation with the prediction of military ability. Research by Foulis et al. (2017) also showed that tests constructed in such a way do not have a high statistical prediction. In this regard, a new set of tests was constructed in the US Army to be used in the selection. The test battery included the following tests for power assessment: strength deadlift, standing power throw, push-ups and leg tuck (Cox, 2018).

Based on the above mentioned, the purpose of this study is to determine the predictive models of the time scored on the military readiness obstacle course by determining muscular strength of PMP in SAF.

METHODS

Subjects

The study included 17 PMP of SAF, aged 25 to 32. The mean values (SD) of their age, body weight, height and BMI were 27.71 ± 7 years, 85.94 ± 33 kg, 1.82 ± 0.17 cm and 25.86 ± 8.60. kg·m^{-2}. All military personnel were qualified for their occupations in their units, with a minimum job tenure of three years in SAF. Their physical readiness varied from the work required physical exercise to leisure physical activities. All participants were given a consent to perform necessary measurements, after which they were subjected to a medical examination to obtain confirmation that they are physically capable to perform necessary motor tasks during the examination. Military personnel who have been identified with immediate or acute injuries, as well as other illnesses, were excluded from the research. Participants were given instructions to continue to apply their regular every day exercise routine during the duration of the research. Prior to the start of the research, the participants were familiar with the Security and Health Protection at Work prescribed by the Sports Regulation in SAF (Ministry of Defence, 2011). The commandmant of the 126.brVOJIN unit approved the research in this unit.

Procedure

The measurements were made in the period from March to June 2018 at the sports fields of the respective unit. All the measurements were carried out by pre-trained persons, i.e. professors of physical education. On the first day of the survey, participants were introduced with the test procedure in detail, and then they approached to the measurements of anthropometric characteristics. On the second day of the survey, participants approached the measurement of motor skills. The tests for the assessment of upper extremity streinght were carried out first, followed by the tests for the assessment of low extremity streinght. On the third day, participants were tested on the military obstacles course (Ministry of Defence, 2011). During the research, participants carried sports equipment for measuring motor skills and camouflage uniforms M-10 with boots used for military training. Each day of testing began with warming-up, instructions, and description of exercises on testing.

Outcome measures

Body height (HIGHT) was measured with an accuracy of 0.1 cm using a standardized anthropometric instrumentarium (GPM, Switzerland). The body mass (MASS) was measured with an accuracy of 0.1 kg on a standardized digital balance (Beurer BF 66). Based on the obtained results of body height and mass, BMI was calculated using a standardized formula κγ•μ^{-2}.

Motor Abilities Tests

(1) Tests for the assessment of upper extremities muscular strength.

1. Push-ups for 60 s (PUSHUP / frec). The aim of this test is to perform as many push-ups as a participant can in one minute. The starting position is with participants arms straight, elbows locked, body straight, hands placed slightly wider than shoulder-width apart with fingers pointing forward and both feet on the floor. From the starting position, on the command 'go,' a participant starts the push-up by bending his elbows and lowering his body until the shoulders drop below the level of the elbows, then return to the starting position. Pausing to rest is permitted only in the up (starting) position (Wood, 2008).

2. Seated Medicine Ball Throw (SEATMT / cm). The aim of this test is to throw as far as possible a medicine ball. The participant sits on the floor with his legs fully extended, feet 60 cm apart and the back against a wall. The ball is held with the hands on the side and slightly behind the center and back against the center of the chest. The forearms are positioned parallel to the ground. The participant throws the medicine ball vigorously as far straight forward as he can while maintaining the back

against the wall. The distance thrown is recorded. The participants had the right to repeat throwing three times (Wood, 2008).

3. Flexed-Arm Hang Test (ARMHNG / s). Grasp the overhead bar. The overhand grip was required. Position the body with the armed flexed and the chin clearing the bar. The chest should be held close to bar with legs hanging straight. The subjects were assisted to this position. The subject hold this position for as long as possible. Only one trial was required (Bala et al., 2007).

(2) Tests for the assessment of explosive strength.

1. Standing Long Jump Test (LJUMP / cm). The participant stands behind a line marked on the ground with feet slightly apart. A two foot take-off and landing is used, with swinging of the arms and bending of the knees to provide forward drive. The subject attempts to jump as far as possible, landing on both feet without falling backwards. Three attempts were allowed (Bala et al., 2007).

2. Seated Medicine Ball Throw (SEATMT / cm). The aim of this test is to throw as far as possible a medicine ball. The participant sits on the floor with his legs fully extended, feet 60 cm apart and the back against a wall. The ball is held with the hands on the side and slightly behind the center and back against the center of the chest. The forearms are positioned parallel to the ground. The participant throws the medicine ball vigorously as far straight forward as he can while maintaining the back against the wall. The distance thrown is recorded. The participants had the right to repeat throwing three times (Wood, 2008).

3. Kneeling Power Ball Overhead Throw (KNEEMT / cm). The athlete starts by kneeling with the back erect, facing the direction they are going to throw. The thighs should be parallel and the knees at the start line. Starting with the ball grasped with both hands at the sides, and held out in front of the body. The ball is brought back over the head, then in one motion the ball is pushed forward and up (optimally at about 45 degrees). Several practices may be required to get the best trajectory for maximum distance. You must not throw favoring one arm or rotate about the spine. The athlete is permitted to fall forward over the line after the ball is released. The knees are not to leave the ground, or the toes used to gain extra traction. Three attempts are allowed (Wood, 2008).

A Military readiness obstacle course

MSKILL is designed to simulate crossing a battlefield with scattered obstacles. It is composed of 18 different obstacles arranged on a 240 m long section. Obstacles: wire mesh, a fence made of undergrowth, palisades, logs, two beams, scaffolding, horizontal ladders, a wire fence, a shaft, combined ladders, three beams, holes, doors and windows, a tunnel, horns, a corridor, sloping palisades, a trench. The initial position of the participants was foreground lying. On the command “go”, the participants had to overcome the obstacles as fast as they could. Walking was allowed during testing. The time required to complete the test was measured in seconds. The participants had the right to repeat the section twice. In cases where participants failed to run the course as instructed, disqualification was determined (Ministry of Defence, 2011).

Statistical analysis

Descriptive data were calculated for anthropometrics and motor abilities. The results are presented by mean ± standard deviation (SD). The Pirson coefficient of correlation was used to determine the relationship between the predictor and the criterion variables (one with each of them). The values of this coefficient range from -1 to +1. The regression analysis was used to determine the impact of agility and aerobic ability on military readiness course. Statistical analyses were conducted in Statistica 8.0. The level of statistical significance was taken for $p < 0.05$.

RESULTS

Table 1 shows basic statistical parameters of the general indicators of the sample. By analyzing them, it was found that the participants’ included in this study was average aged 28 (27.71 ± 7.00), body height 182 cm (1.82 ± 0.17), body weight 86 kg (85.94 ± 33.00), and BMI 26 (25.86 ± 8.60).

Table 1. Basic statistical parameters - general indicators of the sample

Variables	N	Mean	Min	Max	Range	SD
YEAR	17	27.71	25.00	32.00	7.00	2.592
HIGHT	17	1.82	1.76	1.93	0.17	0.050
MASS	17	85.94	68.00	101.00	33.00	9.562
BMI	17	25.86	21.60	30.20	8.60	2.571

By analyzing Table 2 in which basic statistical parameters of upper arm muscular straingth and explosive strength of PMP are shown, It can be seen that these tests showed an excellent variability. By screening the result, a normal symmetry of distribution around the arithmetic mean can be seen in almost all motorics tests. Kurtosis indicates that the results in all variables are in a normal distribution. The results of LJUMP are slightly spread out.

By inspecting basic statistical parameters of MSKILL, it can be noticed that the results have an excellent discrimination. The best time scored on MSKILL is 86 s, while the weakest is 230 s. By screening the results, the distribution of data around the arithmetic mean is symmetric, and the results are in normal distribution.

Table 2. Basic statistical parameters of predictor variables and criterion variables

Variables	N	Mean	Min	Max	Range	SD	Error	Skew	Kurt
PUSHUP	17	48.41	23.00	80.00	57.00	13.519	3.279	0.310	0.712
SEATMT	17	537.65	420.00	650.00	230.00	59.847	14.515	0.123	-0.084
ARHANG	17	44.06	0.00	100.00	100.00	25.285	6.132	0.399	0.351
LJUMP	17	221.76	200.00	248.00	48.00	16.130	3.912	0.088	-1.400
SEATMT	17	537.65	420.00	650.00	230.00	59.847	14.515	0.123	-0.084
KNEEMT	17	743.53	560.00	970.00	410.00	112.580	27.305	0.485	-0.418
MSKILL	17	160.12	86.00	230.00	144.00	36.662	8.892	0.446	0.643

Table 3 shows intercorrelations of the variables for assessing the upper arm muscular strength and MISKILL with the help of Pirson's correlation coefficient. By its inspection, it can be noticed that all the variables are positive, and that the variables statistically correlate significantly with each other. The exception are variables ARHANG and SEATMT. The highest coefficient of the correlation is between ARHANG и PUSHUP ($r = 0.91$, $p < 0.05$), and the weakest is between PUSHUP and SEATMT ($r = 0.52$, $p < 0.05$).

By analyzing the intercorrelation variables for assessing the upper arm muscular strength and MSKILL, it is noted that all the coefficients are statistically significant and negative. The highest coefficient of correlation with the criterion variable has ARHANG ($r = - 0.86$, $p < 0.05$), considerably weaker PUSHUP ($r = - 0.84$, $p < 0.05$) and the weakest SEATMT variable ($r = - 0.62$, $p < 0.05$).

Table 3. Intercorrelations of variables for the assessment of upper arm muscular strength and MSKILL

Variables	VO2MAX R	VO2MAX A	T2400	MSKILL
PUSHUP	1.00			
SEATMT	0.52	1.00		
ARHANG	0.91	0.47	1.00	
MSKILL	-0.84	-0.62	-0.86	1.00

Table 4. Intercorelations of variables for the assessment of explosive strength and MSKILL

Variables	REJUMP	SHUTTLE	T-TEST	MSKILL
LJUMP	1.00			
SEATMT	0.34	1.00		
KNEEMT	0.50	-0.01	1.00	
MSKILL	-0.58	-0.62	-0.42	1.00

Table 4 shows the intercorrelations of the variables for assessing the explosive strength and MSKILL. It can be noted that KNEEMT and SEATMT are negative and that only KNEEMT and LJUMP variables correlate significantly with each other. In other variables there is no statistically significant association.

By analyzing the intercorrelation of the variables for assessing the explosive strength and MSKILL, it is noted that there is a low to moderate level of statistical significance for variables LJUMP ($r = -0.58$, $p < 0.05$) and SEATMT ($r = -0.62$, $p < 0.05$), and that all of them are negative.

By analyzing these intercorrelation variables for assessing upper arm muscular strength and explosive strength and MSKILL, it can be assumed that ARHANG ($r = - 0.86$, $p < 0.05$) plays a major role in the predictions of MSKILL, and then PUSHUP ($r = - 0.84$, $p < 0.05$).

In accordance with the objective and tasks of the research, the regression analysis will show the proportion between the upper arm muscular strength and MSKILL, and the explosive strength and MSKILL, and to what extent the upper arm muscular strength and explosive strength can influence achieving better time on MSKILL.

Variables	r	Part - r	b	Std.Err. - of b	t(13)	p-value
Table 5. Regression analysis of MSKILL using the upper arm muscular strength						
PUSHUP	-0.84	-0.196	-0.592	0.819	-0.722	0.483
SEATMT	-0.62	-0.442	-0.154	0.087	-1.778	0.099
ARHANG	-0.86	-0.458	-0.790	0.425	-1.856	0.086
R = 0.900	**R^2 = 0.810**	**F(3,13) =18.488**				**p < 0.00006**
Table 6. Regression analysis of MSKILL using the explosive strength						
LJUMP	-0.58	-0.294	-0.548	0.495	-1.107	0.288
SEATMT	-0.62	-0.626	-0.334	0.115	-2.892	0.013
KNEEMT	-0.42	-0.387	-0.101	0.067	-1.513	0.154
R = 0.781	**R^2 = 0.610**	**F(3,13) = 6.784**				**p < 0.00541**

The relationship between the overall system of upper arm muscular strength and MSKILL was 0.90 ($R = 0.90$; $R^2 = 0.80$, $p < 0.05$). These results give a statistically significant explanation of the criterion variable by means of the upper arm muscular strength system ($p < 0.00006$), so that it can be concluded that the upper arm muscular strength system has a statistically significant effect on military training.

By analyzing the individual regression coefficients, one can conclude that no coefficient is individually statistically significantly related to the criterion variable MSKILL.

The relationship between the overall explosive strength and MSKILL was 0.78 ($R = 0.781$; $R^2 = 0.610$, $p < 0.05$). These results give a statistically significant explanation of the criterion variable using the explosive strength ($p < 0.00541$), so it can be concluded that the explosive strength system has a statistically significant effect on military training.

By analyzing individual regression coefficients, it can be concluded that only the coefficient of variable SEATMT ($p < 0.013$) is significantly related to the criterion variable MSKILL.

DISCUSSION

The aim of this research is the development of predictive models of physical abilities necessary for solving tasks in the battlefield when performing military tasks.

This research includes tests for the assessment of upper arm muscular strength and explosive strength in order to determine their connection with the required military task in the SAF. A set of tests for estimating the upper arm muscular strength is considered in three dimensions, by including three strength factors, explosive, repetitive, and static. The constructed set of tests assesses the ability of simple repetitive movements, the ability to maximize energy in one movement in as short as possible time, and the ability of a maximal isometric contraction.

The high association between the upper arm muscular strength and the criterion variable was found ($R^2 = 0.810$, $p < 0.05$). Two tests have a very high correlation with the criterion variable, of which ARHANG has the highest ($r = -0.86$, $p < 0.05$), PUSHUP was slightly weaker ($r = -0.84$, $p < 0.05$), while SEATMT has not shown the association with the criterion ($r = 0.62$, $p < 0.05$). For predicting time on the obstacles, Jetté, Kimick, and Sidney (1989) have come to the conclusion that upper arm muscular strength is in high relation with obstacle course.

The results of previous research have shown a high statistical correlation between explosive strength and military training, especially in long jump and medicine throw tests (Bilzon et al., 2002; Harman et al., 2008, Foulis et al., 2017). In connection with this research, a set of tests for the estimation of explosive strength was constructed where three factors for the estimation of the explosive upper and lower muscular strength and abdomen were were chosen. Such constructed tests evaluate the ability to maximize energy in a single movement in as short a time. The results of these tests showed a statistical correlation with the military task ($R^2 = 0.610$, $p < 0.05$). Two tests have mild statistical association with the criterion variable, of which SEATMT has higher ($r = -0.62$, $p < 0.05$) and little lower LJUMP ($r = -0.58$, $p < 0.05$). KNEEMT did not show a statistical correlation with the military task ($r = 0.42$, $p < 0.05$). Only the coefficient of the variable SEATMT ($p < 0.013$) was significantly related to the criterion variable MSKILL.

From this it can be concluded that the upper and lower explosive strength moderately predicts the capability of military training in the SAF. The explanation can be found in the fact that the sample was small or the test for assessing military training in the SAF does not require this type of strength on that level.

CONCLUSION

This research was concerned to determine the predictive models of the time scored on the military readiness obstacle course in order to implement them in the selection of persons for military service and to monitor physical abilities of those in service. Two sets of variables were selected for assessing upper muscular and explosive strength to determine their prediction in MSKILL. Both sets of variables showed a good prediction of military tasks ($R = 0.900, 0.781$; $R^2 = 0.810, 0.610$, $p < 0.05$).

The results showed that the upper arm muscular strength is a good predictor of military training in the SAF with the highest predictor value of the variables for estimating static and repetitive strength ($r = 0.86; 0.84$, $p <0.05$). Explosive power has a moderate predictor value of military training in VS, where the variable for estimating the explosive power of the upper extremities had the highest single statistically significant association ($p <0.013$).

that T-TEST and VO2MAXA ($r = 0.86$ and $- 0.83$, $p < 0.05$) can be highly efficient in identifying the right candidates for admission to the SAF, who will be able to master military training in order to save time and money needed to be trained with them. Also, by applying this easily applied physical readiness test with PMP, they can effectively monitor their level of physical abilities, while at the same time avoiding the possibility of getting injured.

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RELATIONS BETWEEN PHYSICAL ACTIVITY, ANXIETY AND SYMPTOMS OF DEPRESSION

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SUMMARY

The main aim of this research was to determine the relationship between a degree of physical activity, anxiety as a personality trait and depression. The survey was conducted on a sample of 110 people, 51 of whichbeing female and 59 respondents weremale. All subjects were healthy and aged 18 to 45. The most important result of the study is that higher intensity and frequency of physical activity is associated with reduced anxiety, and it applies only to men.A negative, statistically significant correlation between depression and physical activity was identified.

Keywords: anxiety, depression, physical activity, health

INTRODUCTION

According to the data available to the World Health Organization about 300 million people worldwide suffer from depression. About 800,000 people commit suicide each year, and among people between the age of 15 and 29, suicide is the second leading cause of mortality. (www.who.int). The World Health Organization predicts that by 2020 depression will be the second disease after heart disease that causes disability (World Health Organization, 2002 by Urosevic, Davidovic, Odović, Alexopoulos& Mitrovic, 2010).Anxiety is also increasingly present in contemporary society. One of the most important things in the study of the concept of anxiety are empirical data about different types of anxiety (Cattell &Scheier, 1958; Spielberger et al., 1983; by Ružič, Vidanović, &Stojiljković, 2015) assuming two different types of anxiety - anxiety as a state and anxiety as a trait. In this study, we decided to treat anxiety as a personality trait.

There are three explanations of the effects of physical exercise on psychological factors (Bungić& Baric, 2009). According to Cox (2005), the relationship between physical exercise and psychological well-being determined by scientific research is as follows:

1) Exercise can be associated with reduced anxiety
2) Exercise can be associated with reduced levels of mild to moderate depression
3) Long-term exercise is usually associated with reduced neuroticism
4) Exercise can be an adjunct to the professional treatment of severe depression
5) Exercise can result in a decrease in various stress indicators
6) Exercise can have a beneficial effect on both sexes at all ages.

There are many studies that prove the beneficial effect of physical exercise on psychological characteristics (Biddle, 1995). A study of the effect of physical exercise on people over the age of 60 (Antunes, Stella, Santos, Bueno & Mello, 2005) showed that patients in the experimental group (who were practicing physical activities) had a significant improvement in all the psychological parameters that were being monitored. Some authors (Blumenthal, Babyak & Moore., 1999; Barbour & Blumenthal, 2005) concluded that the elderly depressed patients experienced the same effects in reducing depression after a sixteen-week exercise program as in the treatment with antidepressants, but also emphasize a number of methodological limitations.In another study Blumenthal (Blumenthal et al., 2007), showed that the therapeutic effects of physical exercise are nearly the same as those in antidepressant therapy. A study conducted on a sample of 16,483 students found that there was a significant correlation between exercise and low depression (Stepoe, Wardle & Filler, 1997). The effectiveness and efficiency of physical training in preventing and alleviating depression have also been shown in patients who have hadlong hemodialysis treatment (Suh, Jung, Kim, Park & Yang, 2002).Some authors(Norris, Carroll & Cochrane, 1992) have done research on adolescents, and the results have shown that the experimental group which was involved in the program (high intensity training) reported much less stress after finishing the program. A study was carried out on the general population of Finland, (Hassman, Koivula&Uutela, 2000) and the results obtained indicated that those who exercise at least two to three times a week show significantly smaller number of depression and anxietysymptoms. Some studies, whose task was to determine the relationship between physical exercise and anxiety,consider the type of exercise and examine the impact of both aerobic and anaerobic exercise on the level of anxiety (Martinsen, Hoffart& Solberg, 1989) and claim that there is no difference. Studies (Schwartz, Davidson & Goleman, 1978) also argue that physical exercise significantly reduces the somatic trait of anxiety, while some other activities such as meditation yields better results when cognitive anxiety is concerned. Women practicing yoga report less fear, persistent tension and irritability than those who do not practice recreational physical activities (Kucelin, 2016).

METHODS

The main objective of this study was to determine the relationship between a degree of physical activity, anxiety as a personality trait and symptoms of depression.

The sample consisted of 110 people, 51 respondents were female and 59 male. All subjects were healthy and aged 18 to 45 (57 subjects aged 18 to 30 and 53 subjects aged 31 to 45 years).

IPAQ (International Physical Activity Questionnaires),its shorter version in particular. was used to test the physical activity. The questions in this questionnaire are structured to allow scores for walking, moderate physical activity and vigorous physical activity. In previous studies it is stated that this questionnaire can make the difference between the physically active and inactive participants (Kisko et al., 2013). For each activity so-called MET value can be calculated when the number of minutes of the specific activities is multiplied by the number of days that it is practiced in one week, and the product is additionally multiplied by coefficients for the specified sub-domains. Of course, based on the addition of all three MET for different activities, the total MET for each respondent can also be calculated. D-scale (Novović& Biro, 2009) was used to evaluate the symptoms of depression, and a questionnaire AT29 (Tovilović&Novović, 2009) was used to estimate anxiety as a trait. Pearson's correlation coefficient was used to determine the relationship between variables.

RESULTS

Table 1 presents the correlations of the variables obtained by calculating the Pearson coefficient of correlation on the whole sample. It can be concluded that the presence of depressive symptomatology in the respondents' lives is statistically significant and negatively related to the parameters related to physical activity, except for the number of days a week that respondents go walking. This means that if respondents are more physically active - they are less depressed. Correlations are statistically significant at the level of 0.01. The correlation is low to moderate intensity, and the strongest correlation is between the symptoms of depression and total physical activity. Moreover, anxiety as a personality trait is statistically significant and negatively related to the all parameters of physical activity, with the exception of walking as the least intensive form of physical activity.

Table 1. Correlations between variables of the study in the whole sample

		walking (minutes)	walking (days)	MET walking	moderate (minutes)	moderate (days)	MET moderate	vigorous (minutes)	vigorous (days)	MET vigorous	MET Total
AT 29	Pearson Correlation	-.184	-.037	-.158	-.215*	-.223*	-.312**	-.309**	-.254**	-.334**	-.385**
	Sig. (2-tailed)	.054	.700	.100	.024	.019	.001	.001	.007	.000	.000
	N	110	110	110	110	110	110	110	110	110	110
D scale	Pearson Correlation	-.328**	-.043	-.319**	-.251**	-.455**	-.437**	-.416**	-.415**	-.490**	-.603**
	Sig. (2-tailed)	.000	.658	.001	.008	.000	.000	.000	.000	.000	.000
	N	110	110	110	110	110	110	110	110	110	110

The results presented in Tables 2 and 3 show that there is statistically significant negative correlation of symptoms of depression and physical activity in both younger and older respondents. The only difference is the fact that in the older group of subjects (31 to 45 years) there is no correlation between the number of minutes spent on the daily basis in moderate physical activity and depressive symptomatology of the respondents. Regarding anxiety, we can conclude that there is a significant correlation (negative) in both sub-samples when it comes to total physical activity. However, in the older group of subjects, the negative correlation between anxiety and physical activity is not related to walking, but to moderate and intense physical activity.

Table 2. Correlations between research variables in the sub-sample aged 18 to 30 years

		walking (minutes)	walking (days)	MET walking	moderate (minutes)	moderate (days)	MET moderate	vigorous (minutes)	vigorous (days)	MET vigorous	MET Total
AT 29	Pearson Correlation	-.322*	-.064	-.272*	-.240	-.061	-.250	-.263*	-.099	-.229	-.401**
	Sig. (2-tailed)	.014	.635	.041	.072	.653	.061	.048	.464	.086	.002
	N	57	57	57	57	57	57	57	57	57	57
D skala	Pearson Correlation	-.312*	-.084	-.293*	-.269*	-.450**	-.390**	-.380**	-.551**	-.460**	-.599**
	Sig. (2-tailed)	.018	.533	.027	.043	.000	.003	.004	.000	.000	.000
	N	57	57	57	57	57	57	57	57	57	57

Table 3. Correlations between research variables in the sub-sample aged 31 to 45 years

		walking (minutes)	walking (days)	MET walking	moderate (minutes)	moderate (days)	MET moderate	vigorous (minutes)	vigorous (days)	MET vigorous	MET Total
AT 29	Pearson Correlation	.049	.032	.090	-.143	-.361**	-.341*	-.325*	-.372**	-.409**	-.326*
	Sig. (2-tailed)	.727	.819	.522	.306	.008	.012	.018	.006	.002	.017
	N	53	53	53	53	53	53	53	53	53	53
D skala	Pearson Correlation	-.284*	.058	-.274*	-.171	-.431**	-.433**	-.412**	-.256	-.488**	-.562**
	Sig. (2-tailed)	.039	.681	.048	.222	.001	.001	.002	.065	.000	.000
	N	53	53	53	53	53	53	53	53	53	53

When it comes to the relationship of physical activity to depression and anxiety, the results in Tables 4 and 5 suggest that the negative correlation between the depressive symptomatology and physical activity is constant (present in both sexes as well as in the whole sample). However, when it comes to anxiety, presumed negative correlation with physical activity was foundonly in men, while in women there are no statistically significant correlations between anxiety and any form of physical activity.

Table 4. Correlations between research variables in the male sub-sample

		walking (minutes)	walking (days)	MET walking	moderate (minutes)	moderate (days)	MET moderate	vigorous (minutes)	vigorous (days)	MET vigorous	MET Total
AT 29	Pearson Correlation	-.224	-.066	-.196	-.231	-.357**	-.405**	-.384**	-.423**	-.406**	-.496**
	Sig. (2-tailed)	.088	.619	.138	.079	.006	.001	.003	.001	.001	.000
	N	59	59	59	59	59	59	59	59	59	59
D skala	Pearson Correlation	-.290*	-.093	-.319*	.007	-.471**	-.353**	-.362**	-.377**	-.446**	-.561**
	Sig. (2-tailed)	.026	.483	.014	.959	.000	.006	.005	.003	.000	.000
	N	59	59	59	59	59	59	59	59	59	59

Table 5. Correlations between research variables in the female sub-sample

		walking (minutes)	walking (days)	MET walking	moderate (minutes)	moderate (days)	MET moderate	vigorous (minutes)	vigorous (days)	MET vigorous	MET Total
AT 29	Pearson Correlation	-.126	.002	-.119	-.201	-.091	-.194	-.206	-.061	-.222	-.251
	Sig. (2-tailed)	.378	.987	.405	.156	.525	.174	.148	.669	.117	.075
	N	51	51	51	51	51	51	51	51	51	51
D skala	Pearson Correlation	-.354*	.003	-.316*	-.441**	-.443**	-.503**	-.454**	-.442**	-.529**	-.632**
	Sig. (2-tailed)	.011	.982	.024	.001	.001	.000	.001	.001	.000	.000
	N	51	51	51	51	51	51	51	51	51	51

DISCUSSION

According to the results of this study, the relationship between the presence of symptoms of depression and physical exercise is fairly clear and universal. The negativity of the correlationcoefficient indicates that the respondents are more physically active - they are less depressed. High level of significance (at the level of 0.01) justifies the main goal of the study - to point out that an adequate physical activity (of any degree of intensity) is beneficial to the psychological characteristics and states, in particular to the reduction of depression in everyday functioning.

It can be concluded that there are statistically significant negative correlations between the severity of the symptoms of depression and the degree of physical activity in both older and younger group of subjects. The only difference is that in the older group of subjects (31 to 45 years) there is no correlation between the number of minutes spent on the daily basis doing moderate physical activity and depressive symptomatology of the respondents. Such information can be interpreted in the way that the beginning of the activity itself, and not the duration of the activity, is important for the older group of subjects. Also, a statistically significant negative correlation between depression and physical activity is typical for both gender subsamples (female and male). The universality of the relationship between physical activity and the symptoms of depression is a very significant and encouraging piece of information for all who are trying to implement various physical exercise programs in order to promote the general well-being of people.

The results of the study on the relationship between anxiety as a personality trait and physical activity indicate that a higher degree of general physical activity is related (though not very strongly) to a less presence of anxiety as a personality trait. Particularly interesting are the data that showed the lack of statistically significant correlation between walking as physical activity and anxiety. This finding suggests that walking is probably an activity done to satisfy some other needs (work, purchase, etc.), and not the psychological needs that might be derived from the concept of anxiety as a personality trait. Other forms of physical activity could have their psychological roots. The lack of anxiety correlation with either the duration of walking or the frequency of walking on a weekly basis indicates that such interpretations are justified. However, the relationship of anxiety and physical activity is not universal, as opposed to depression and physical activity. The results obtained on the sub-samples of men and women clearly indicate this. These results are perhaps the most significant of all of the results obtained in this study, since in male sub-sample the assumed negative correlation between anxiety and physical activitywas confirmed, while in female sub-sample there is no statistically significant correlation between anxiety as a personality trait and any form of physical activity. These data are significant because they indicate that caution is necessary in the interpolation of the results obtained in this study to the general population.

CONCLUSION

Summarizing the results presented above, it can be concluded that the higher intensity and frequency of physical exercise is associated with less pronounced anxiety as a personality trait, but only in men. We can also conclude with certainty that people who are more physically active are less susceptible to the appearance of depressive symptoms, and that this relationship is characteristic for both sexes and for all subjects aged 18 to 45 years. This indicates that physical exercise is closely linked not only to physical but also to psychological well-being.

The basic limitations of this study are the absence of older groups of respondents (over 45 years) and poor control of sociopsychological factors that could play the role of moderators in the relationship between anxiety, depression and physical activity. Also, one of the weaknesses of this study is typical for this type of research and refers to the adequacy and motivation of respondents to provide introspective psychological data and an accurate estimate of the duration and intensity of physical activity.

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POSSIBILITIES FOR THE DEVELOPMENT OF SOCIAL SKILLS IN STUDENTS THROUGH PHYSICAL EDUCATION AND SPORT

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SUMMARY

Social skills are a key factor in determining the quality and effectiveness of interpersonal interactions. Experimental results on the level of social skills in Bulgarian secondary school students are presented as well as the opportunities for their formation through physical education and sport are pointed. Students who have sports activities under the guidance of a coach for a longer period of time have more developed communication and collaboration skills.

Keywords: students, social skills, physical education and sport.

INTRODUCTION

Everyday people interact with each other, both through interpersonal contacts and within small and large social groups. Social skills of the participants are the main factor that determines the quality and effectiveness of these interactions. In international documents of strategic importance for the development of society, social skills are seen as a prerequisite for public prosperity, and their personal relevance is equivalent to professional skills

Social skills are the subject of active research, especially over the past two decades. There are different definitions in which they are defined as: "patterns of social behavior that make individuals more competent, ie. more capable of inducing the desired effect on other individuals "(Argyle, 1994); "All the things we have to say and do when interacting with other people" (Novotni, 1999); "Behavior that allows students to act and interact with their peers and the surrounding world in a socially acceptable way" (Sheridan, 2000).

Many researchers are looking at social skills in the context of social competence. According to Cavell (1990), social competence is a three dimensional construct that includes social adaptation, social performance and social skills. According to Spens (2003), social skills are a precondition for a successful response in certain situations and a form of manifestation of social competence. Dam & Volman, (2007) point out that social competence covers both skills and attitudes, knowledge, reflection (reflection and understanding of the situation) that occur in interpersonal and intrapersonal interactions. Tosheva (2016) includes social skills within a broader construct of social competence that reflects the quantity and quality of possessed knowledge and beliefs of the essence of the interactions and self-representation in them. Skills are the practical manifestation of social competence. They facilitate interpersonal interactions and communication on the basis of social rules and relationships.

Some authors link the definition of social skills with their impact on others and the positive outcome for their holder (Cartledge & Milburn, 1995), with flexible adaptation to diverse social conditions and requirements (Bierman & Welsh, 2000).

Social skills are practiced through a large number of verbal and non-verbal means. These include smile, gossip, caressing, expressing friendship, expressing feelings and opinions, defending your own position on a particular issue, conducting a conversation, etc. (Samalot-Rivera, Porreta, 2009). These reactions can be quantitatively and qualitatively regulated to best influence both the perception and the response of other people during the interaction. In visual contacts, the expression of the face, the posture of the body, the distance between the participants and their gestures are of particular importance. All of them should be well balanced with the cultural norms and the peculiarities of the social situation in which they are applied. In the same way, verbal means such as voice tone, volume and clarity of spoken speech, speech speed, etc. are also subject to regulation. The way of using these means forms the impression that each participant makes to the other and prepares the basis for his reactions (Spens, 2003).

Riggio (1986) develops a theoretical framework that includes six main dimensions of social skills, namely: obtaining information; sending information; communication control - in two divided areas, emotional expression and emotional sensitivity; social expression; social sensitivity; control of emotions.

Canney & Byrne (2006) divide the skills into four groups: basic skills (ability to maintain eye contact, appropriate personal space, understanding gestures and facial expressions), interaction skills (conflict resolution, and ending conversations, defining appropriate topics for conversation, authoritative argumentation); the affective skills needed to understand oneself and others (identifying feelings, demonstrating empathy, decoding body language and facial expressions, determining whether someone is trustworthy); cognitive skills needed to maintain more complex social interactions (social perception, choice, self-control, understanding of community norms, defining appropriate behavior for different social situations).

Social skills are mastered as a result of a long and complex process - socialization. The process takes place under the influence of many factors from the environment in which the young person's personality grows and shapes The most important is the influence of the family, the school, the friendly environment.

In modern societies, school education covers much of the life of children and adolescents. This is the time when they acquire various scientific and practical knowledge related to future professional realization and the most appropriate time to master many social skills that underlie successful adaptation to major segments of the social environment. In this sense, the school has a leading role as a factor in shaping social skills. Every day, students face the challenge of coping with a wide range of challenging social situations. For the successful management of their social life, they need to have a "sophisticated repertoire" of social skills as part of their personal capacity to deal with problems. The lack of social skills in pupils reduces their engagement with the school environment, as a result of which their level of achievement falls and negative behavior and health changes occur (Durak et al., 2011). Pro-social behavior in the classroom is associated with positive intellectual outcomes (Zins et al., 2004). Educators should be aware of the essence of social competence in detail, record deficits and know how to recover them. There is sufficient evidence that social skills deficits are the basis of many emotional and behavioral problems (Spens, 2003).

The influence of physical education and sport on the formation of the social skills of the students is quite specific. Holt et al. (2008; 2009) stresses that the positive outcomes of adolescent sports activities as far as their social skills are concerned are not regular, but rather can be defined as "conditional". The social skills education should include certain techniques and interactions of children and adolescents with "key social agents" - peers, parents and coaches in the context of sports activities. It is extremely important for sports educators to direct children and adolescents towards collective goals and to inspire in different ways the idea of empathy and the importance of every athlete in the realization of these goals. They have to prioritize personal development in the pursuit of sporting outcomes. The experience gained in the sports activities can be applied in other spheres. It is a kind of life capital from which students can benefit throughout their lives (Gould, Carson, 2008, Goudas, 2010). These "intrinsic personal assets and characteristics are related to goal setting, emotional control, self-esteem, solid and consistent work ethics, they can be developed in sport and applied to areas outside of the sport" (Gould, Carson, 2008, 229).

METHODS

The aim of the study is to investigate the level of social skills in Bulgarian secondary school students and the opportunities for their development through physical education and sport. The tasks of the survey cover: 1 / Establishment of the level of students social skills according to their own assessment and according to the teachers' assessment; 2 / Study the teachers' opinion on the opportunities for development of social skills through physical education and sport education.

The subjects of study are 82 students (VIII-XII grade) from schools in the cities of Sofia and Plovdiv. 36 of them are girls and 46 are boys. At the time of the study, they were at the age of 13 to 17 years old (M = 15.1, SD = 1.28). Most of them (79.3%) are under the guidance of a coach, 55 have a sports training of up to 5 years and 10 have a sports training over 5 years. The study also includes 26 teachers in physical education and sports (15 women and 11 men) with a pedagogical experience between 1 and 31 years (M = 10.5, SD = 8.6).

Methods of study:

Social Skills Testing for Secondary School Students. The test has been developed and probed for this survey. It includes 24 items that are divided into 6 subscales - empathy, community, assertiveness, self-control, responsibility and co-operation. The students indicate the frequency of a particular behavior using a 4-degree Likert type scale: never, almost never, often, always. The value obtained under the Crombach Alpha criterion is $\alpha = 0.86$.

Expert evaluation. This method is applied in order to investigate the evaluation of two problems - to what extent the students possess the investigated skills - sociability, assertiveness, empathy, self-control, responsibility and cooperation; what is the influence of the main factors for social skills development such as family, school, physical education, friendly environment, out-of-school sport under the guidance of a coach.

Poll. It includes five questions for teachers concerning the programs implemented in their schools in relation to the development of social skills as well as the real opportunities to include methods and techniques for the development of social skills in physical and sports education. Two of the questions in the questionnaire are related to the competence of the teachers, their motivation and the opportunities for enhancing their competence.

The statistical processing was performed by frequency analysis; variance analysis, comparative analysis (Mann-Whitney U for independent variables). The results are processed through the statistical program "SPSS 23 for Windows".

RESULTS

Data on the level of social skills have been analyzed for all students and are also grouped by gender, class, age, sport activity, sporting experience, residence.

Students give the highest grade of their communication skills. In this case, they relate to their ability to communicate verbally - to send clear verbal messages and, accordingly, to understand the messages they receive from others. They give the lowest score, (with the same values) to their self-control and cooperation skills. Overall, there are no significant differences in the level of development of different skills. From this it can be concluded that the development of different skills in the process of socialization takes place at the same time and it is likely that each one has a stimulating effect on others (Table 1).

According to the expert assessment of the teachers, the students best developed skills are responsibility ($M = 3.58$, $SD = 0.81$), empathy ($M = 3.58$, $SD = 1.03$); $SD = 1.03$). For all skills, girls are rated higher than boys (Figure 1). The greatest difference was found with respect to empathy ($U = 4.73$; $\alpha = 0.001$) and the ability to communicate ($U = 3.24$; $\alpha = 0.001$). The difference in the self-control skill is the lowest ($U = 2.24$; $\alpha = 0.05$).

Table 1 Average values of social skills in pupils

Social skills	N	Min.	Max.	M	SD
Communication	82	2,25	4,00	3,25	0,39
Assertiveness	82	1,50	4,00	2,88	0,60
Empathy	82	1,00	4,00	3,07	0,72
Self-control	82	1,00	3,75	2,82	0,67
Collaboration	82	1,00	4,00	2,82	0,65
Responsibility	82	1,00	4,00	3,21	0,69

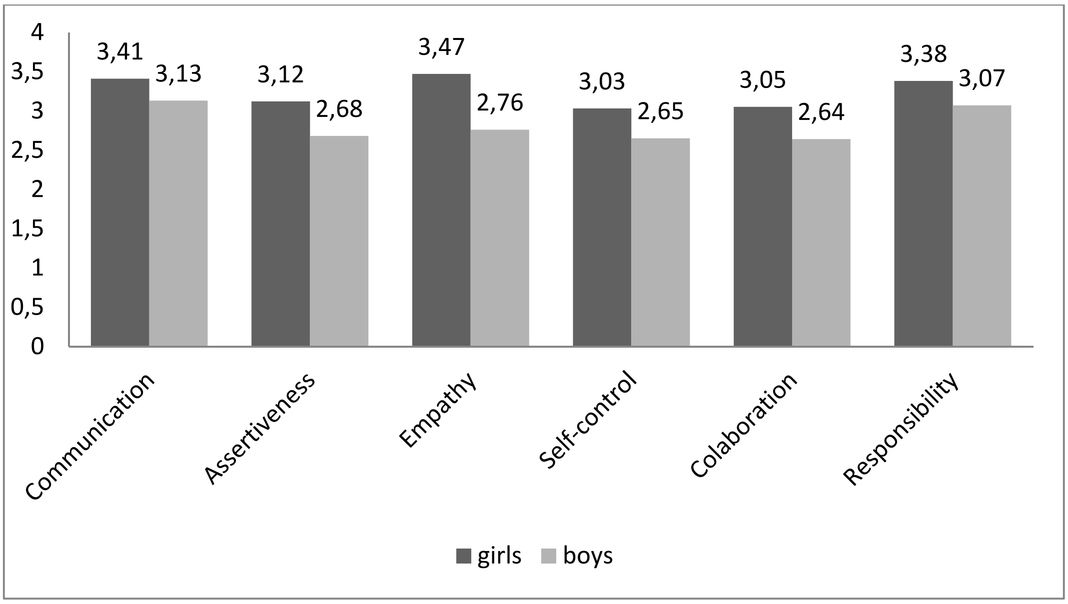

Figure 1. Average values of social skills by gender

There are no significant differences found as far as class and age indicators are concerned. One possible explanation for this result is that there are students of different ages in the same class. For example, students in the 8th grade are aged between 13 and 15, and in the 12th grade between 16 and 17. Changes in the development of social skills over a one-year period take place too slow and can not be successfully registered with a similar type of survey.

In order to determine how and to what extent sport activities influence the formation of social skills, we divided the surveyed into two groups - with a sports experience of up to 5 years and with a sports experience over 5 years. Comparative analysis revealed significant differences in social communication skills ($U = 2.00$; $\alpha = 0.05$) and in co-operation skill ($U = 1.98$; $\alpha = 0.05$). Higher scores are registered for students with greater sporting practice (Figure 2).

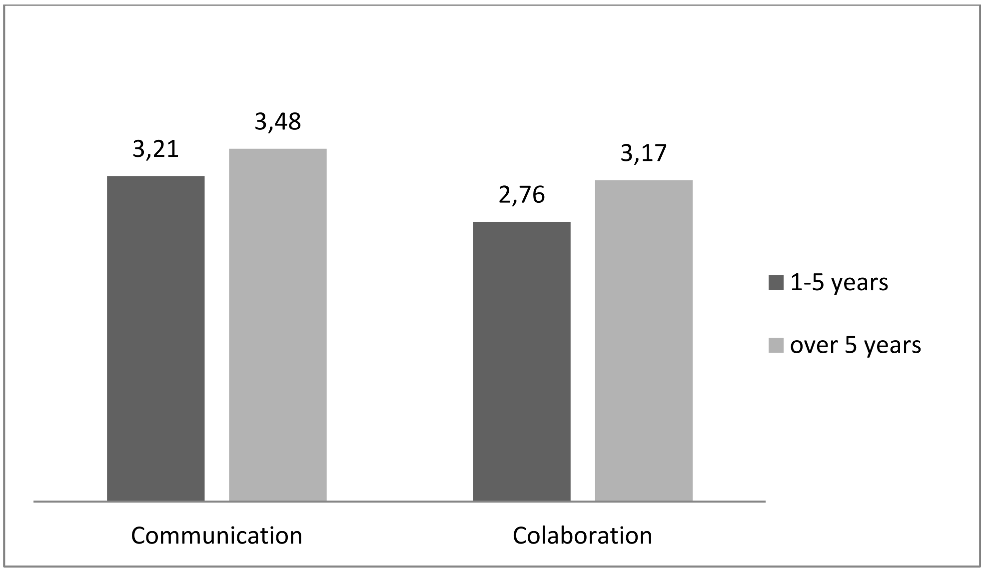

Figure 2 Significant differences in social skills in the sport performance indicator.

According to teachers' estimation, the factors that most strongly influence the formation of the social skills of the students are the family (M = 4,54, SD = 0,65) and the friendly environment (M = 4,35, SD = 0,69) . They estimate the impact of sports and sports activity (M = 3.88, SD = 1.18) stronger than that of the school (M = 3.42, SD = 0.86). The majority of teachers (69.2%) believe that the learning process in physical education provides greater opportunities for teachers to deliberately influence the formation of the social skills of the students compared to the teaching process in other disciplines. This opinion is characteristic, above all, for teachers with a pedagogical experience of over 15 years and for young teachers - with experience of up to 5 years. The application of certain skills development techniques such as "Fair play", "Working in a team", "Soft communication" can be successfully integrated into the physical education process, according to 86.5% of the teachers.

An important precondition for developing the social skills of students through physical education and sports education is the competence of teachers in this respect. Leading importance among sources of competence is self-preparation, as it is indicated by more than half of the teachers (53.8%). This result can be assessed as positive in terms of the fact that teachers are interested in the problem and are willing to devote time and effort to enrich their knowledge. At the same time, self-preparation has some risks - the possibility of informing from not sufficiently theoretically and practically correct sources, difficulties in orientation on individual aspects of the problem, etc. Almost half of the teachers have received some basic knowledge of social skills during their studies but less than ¼ have additional qualifications. All teachers declare readiness to receive a qualification, with 53.9% attending only high-quality courses that offer up-to-date information. These responses outline a problem that matters for the entire education system and its decision must be guaranteed by the governing bodies.

A question is included in the questionnaire to find out in which schools special programs are being developed to develop social skills that physicists are aware of. Only 30.8% of teachers gave a positive answer to this question. The bulk of them - 38.4% said they did not apply such programs to their schools, and 30.8% did not know about the existence of such programs. There is still too little and non-systematic use of the capacity of the school institution to have a positive impact on improving pupils' social competence.

DISCUSION

The relationship between physical education and physical development of students has been repeatedly examined and numerous positive evidence has been provided, but there are many unclear questions about other areas, including social and emotional development (Bailey, 2006). There are very few experimental results that can be compared to those in the present study. The higher level of social skills in the girls included in this study is in line with the theoretical guidelines for more rapid development of teenage girls and their greater sensitivity to the emotions and problems of others. -Slavin. The majority of teachers believe that physical education provides greater opportunities for social skills. Svoboda, 1999) confirms the same thesis because of the active communication of students and the assumption of different social roles. A higher level of cooperative and com- petitioning skills for sports students is also found by other authors (Tosheva, Holt., 2009).

CONCLUSION

The purposeful formation and development of social skills in students is a prerequisite for their successful adaptation to the social environment and their successful realization under the contemporary conditions. Good social skills are the foundation of young people's self-esteem and their positive self-esteem. One of the most effective means of their formation in school, as a social institution, is physical and sports education. It involves intensive interaction between students; they are involved in collective action to achieve common goals, especially in sports games; they are trained in an emotionally saturated atmosphere, adhere to generally accepted rules. Sport activities, under the guidance of a coach for a longer period of time, stimulate the development of communication and collaboration skills. The main possibilities for improving the development of social skills in students through physical and sports education are related to the implementation of special programs and applying of certain techniques in schools, as well as to enhancing the competence of teachers through their participation in modern and effective forms for additional qualification.

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EVALUATION OF KNOWLEDGE AND ATTITUDES ON DOPING IN SPORT AMONG STUDENTS

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SUMMARY

Objective: Many athletes from the recreational and competitive levels often use various food and dietary supplements and quite often over the counter medicines (OTC). In spite of that fact, doping awareness among students and medical professionals is limited. Professional trainers, doctors and pharmacists represent the first line of valid information for all those who deal with sports.

The aim of this study was to investigate the knowledge and attitudes towards doping in sports among students of medicine, pharmacy as well as among students of faculty of sports and physical education.

Methods: This survey was a cross-sectional study. The data collection was performed using a questionnaire, as a non-standard research technique. The questionnaire included 20 items which related to attitudes and information about doping in sports. Chi-square test was used for comparisons between groups of students. The p<0, 05% was considered as statistically significant.

Results. The study included 262 students (91 students of Faculty of sports and physical education, University of Nis, 86 students of integrated academic studies of pharmacy -IASP and 85 students integrated academic studies of medicine-IASM of Faculty of Medicine. The mean age was 23, 28 ± 1,93 years (range 20–32 years). The female to male ratio was 55.73% and 44.27%, respectively. 184 (70%) students were engaged in sports (27,18% professionally and 72,82% recreationally). A statistically significant difference was found between all groups of students concerning the level of information about the doping (Chi=14,622, p<0,05). Most students opposed the use of doping in sports, but 37% of respondents gave a positive answer. Most students university had a positive attitude about the use of supplements and drugs in sports (54,02%), but there were significant differences between groups of students (p<0,001).

Conclusion. The results of this study showed that students have insufficient knowledge on different aspects of doping in sports. The obtained results point to the need for further education of students in order to avoid accidental doping in sports.

Keywords: doping, students, knowledge, sport

INTRODUCTION

For athletes across a wide spectrum of sports, the use and abuse of medicines, dietary supplements and other substances has become a common and problematic phenomenon. In the case of illness of injury, athletes as other patients, seek medical care and over-the-counter (OTC) medicines. Doping is not only the use or attempted use of prohibited substances or methods by athletes, but also can be committed by anyone who assists in, or covers up a doping rule violation (Shibata, 2017; Saito, 2013). In Serbia, there are many easily accessible OTC medicines that contain prohibited substances. Although all athletes are expected to recognize and understand the World Anti-Doping Code (WADC) regulations, this is sometimes very difficult; therefore, the help of more knowledgeable professionals, such as pharmacists, doctors and trainers, is needed. Despite the prevalence of doping in sport and the need for doping prevention strategies information about doping awareness among students is limited. The *List of Prohibited Doping Substances and Methods* is published every year, outlining substances and methods prohibited in competition and out of competition (Birzniece, 2015). Such activity is strictly prohibited by the WADC. Professional trainers, doctors and pharmacists represent the first line of valid information for all those who deal with sports (Sjöqvist, 2008).

The aim of this research was to establish the level of knowledge and attitudes towards doping and use of drugs and supplements in sport among students of medicine, pharmacy as well as among students of faculty of sports and physical education, in the University of Nis

METHODS

Subjects

The study included 262 students selected of medicine, pharmacy and faculty of sports and physical education, University of Nis of both sexes and different age (20-32 years), According to power analysis (sample size of n= 975, confidence level 95%, confidence interval 5%),

Procedure

This survey was a cross-sectional study conducted during the school year 2017/18. The data collection was performed using a questionnaire, as a non-standard research technique. The questionnaire included 20 items which related to attitudes and information about doping and use of drugs and supplements in sports.

Statistical analysis

The gathered data were processed and analyzed using a computer program SPSS for Windows - version 16.0 (SPSS Inc. USA). Chi-square test was used for comparisons between groups. The p<0,05% was considered as statistically significant.

RESULTS

The study included 262 students (91 students of Faculty of sports and physical education, University of Nis, 86 students of integrated academic studies pharmacy -IASP and 85 students integrated academic studies medicine-IASM of Faculty of Medicine. The mean age was 23,28 ± 1,93 years (range 20 – 32 years). The female to male ratio was 55.73% and 44.27%, respectively (Table 1.).

Table 1. Basic characteristics of the students

	N	%	
Sex			Chi=46.30, p<0.001
female	146	55,73	
male	116	44,27	
Students			
Faculty of sport	91	34,73	
Pharmacy	86	32,82	
Medicine	85	32,44	
Years of study			Chi=344,76, p<0.001
2	91	34,73	
4	36	13,74	
5	103	39,31	
6	32	12,21	

The survey showed that 184 (70%) students are engaged in some sport (27,18% professionally and 72,82% recreationally). The most popular sport was basketball (N = 29, 11.07%). A statistically significant difference was found between the groups of students in the level of information about the doping (Table 2.)

Most students university had a positive attitude about the use of supplements and drugs in sports (54%), where there were significant differences between groups of students (p<0,001). At least the medical students had a positive attitude about the use of drugs and supplements in sports (37%). When it comes to the connection between doping and health, many students are aware that doping is a health risk, but also think that athletes are often not aware of it. There was a difference in knowledge of the list of prohibited substances and methods in sports. Most students opposed the use of doping in sports, but 37% of respondents gave a positive answer (Table 2.).

Table 2. Attitudes of students to doping and use of drugs and supplements in sports.

Attitude regarding the use of medi-cines and/or supplements in sports	N	%	Chi=26.553,p<0.001
I agree	141	54,02	
Unjustified	102	39,08	
Forbidden	18	6,90	
Knowledge of Prohibited List of Substances and Methods			Chi=14.622, p<0.05
Yes	114	55,38	
I am not sure	65	25,00	
I do not know	51	19,62	
Attitude of using doping			Chi=6.074, p=0.19
Yes, Improved results	97	37,02	
Necessity	16	6,11	
Do not need doping	149	56,87	
Do you use or have used doping agents sometimes?			Chi=8.28,p<0.05
Yes	10	3,88	
No	248	96,12	
Do you use some drugs and / or supplements in order to improve your health and / or your sporting results?			Chi=10.645, p<0.05
No	190	73,93	
Sometimes	59	22,96	
Always	8	3,11	

There was a difference in knowledge of the list of prohibited substances and methods in sports among students of medicine, pharmacy and faculty of sports and physical education (Chi=14.622, p<0.05). Results presented in Table 2. showed that a small number of students is well informed about basic documents on doping, such as the *Prohibited List and Law on prevention of Doping in Sports* (Table 3.). Students of faculty of sports and physical education sports are better informed about the prohibited list compared to medicine and pharmacy students (66% vs. 53% vs %).

Table 3. Prohibited List of Substances and Methods

Substances and Methods always prohibited (at the competition and outside competitions)	**Substances and Methods prohibited at thecompetition**
S0. Drugs in clinical trials	S6. Stimulants
S1. anabolic steroids	S7. Narcotics
S2. Peptid hormones, growth factor and related supstances	S8. Cannabinoids
S3. Beta2agonists	S9. glucocorticosteroids
S4. Hormones i metabolic modulators (at the competition and outside competitions)	**Substances prohibited in certain sports**
S5. diuretics and other masking agents	P1. Alcohol
Prohibited methods	P2. Beta blockers
M1. Improving oxygen transport	
M2.Chemical and physical manipulation	
M3. Genetic doping	

DISCUSSION

Doping in sports is as old as sports, but it grew remarkably during the 20th century, especially during the 1990s with development of amphetamines and anabolic steroids, as well as peptide hormones such as human growth hormone (HGH) and erythropoietin (Müller, 2010; Mottram,2011). Laure et all (2004) published the results obtained through interviewing, according to which the prevalence of doping is 3-5% among children and secondary school athletes and 5-15% among adult athletes. The percentage is the highest among sportsmen between ages 20-25, whereas it grows proportionally with the competition level (Laure, 2004). All substances prohibited in sport are listed on a single list that changes at least once a year and which is officially published in English on the World Anti-Doping Agency (WADA) website and in Serbian on the ADAS website (Conway, 2002; Dikic, 2016) . The *List of Prohibited Doping Substances and Methods* is published every year, outlining substances and methods prohibited in competition and out of competition. Our results showed that a small number of students are well informed about basic documents on doping, such as the *Prohibited List and Law on prevention of Doping in Sports*. The vast majority of them agree on the necessity for continuous education about doping rules and forbidden substances, supporting the statement about the wide-spread usage of doping among athletes. When it comes to the questions related to the respondent's knowledge about the specific substances which are used as doping, as well as to the doping procedure, a 55 percent of students answered affirmatively. The answers to the questions about doping substances and doping procedure were mainly statistically significantly different between groups with respect to type of sport ($p<0.05$). In participants' opinion, the most important motive for using doping in sports is to achieve victory in the competition (37%), followed by the desire to progress in one's sport career, physical looks, raising self-confidence and succumbing to the influence of others. Athletes in Serbia most often use anabolic steroids (48.57%), cannabinoids (18.57%), stimulants (15.71%) and diuretics (14.3%) (Dikic, 2016). Wiefferink et all. (2008) obtained data according to which the knowledge about doping and its use correlate, but it is not crucial to take it. Study conducted in Japan that investigated pharmacy students' interests and comprehension regarding drug usage, doping and supplement intake also indicated that the students did not have opportunities to learn about doping and supplement intake (with only 16% of the students attending lectures by specialists on doping) and that their basic knowledge regarding doping was limited (Saito, 2013). More education about doping for pharmacy and medicine students would be as effective for anti-doping activities as is education of athletes.

CONCLUSION

The results of this study showed that students have insufficient knowledge on different aspects of doping in sports. Their knowledge should be on a higher level in order to avoid accidental doping. The obtained results point to the need for further education of students on doping in sports. It is important to provide more opportunities for appropriate education of students on the topic of doping, because students have a potentially significant role to play in doping prevention and in promoting the rational, safe, and effective use of medications in sport.

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SECULAR TRENDS IN CHILDREN AND ADOLESCENT PHYSICAL ACTIVITY BEHAVIOR: AN ALARM TO INCREASE PHYSICAL ACTIVITY

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SUMMARY

A secular trend or secular change in anthropology denotes the process leading to gradual change of average physical measurements of the human body from generation to generation. The indicants of muscle strength and cardiorespiratory endurance expressed related to body mass have shown a constant decreasing trend in younger populations in the last five decades. It was observed that well documented secular increases in body mass and body height, as well as other anthropological parameters, in younger populations in the European Union countries were not accompanied by an appropriate increase in muscular strength and cardiorespiratory endurance. In the past years, several studies were published dealing with the topic of secular changes of anthropometric characteristics and motor ability of children and adolescents aged from 7 to 14 years in Serbia. The observed increased in basic anthropometric measurements did not result in any increases in motoric tests – significantly poorer results were observed instead. Promotion of healthy lifestyles with regular physical activity and adequate nutrition during childhood and adolescence, with prevention measures by professionals to reduce overweight or obesity, is essential for the future of human society and has huge economical, social and demographic implications for the future of each individual country. Regular physical activity of children and adolescents, with the improvement of their nutrition, is an effective and rewarding investment into their future.

Keywords: secular trend, children, adolescents, obesity.

INTRODUCTION

The last several decades brought about significant lifestyle changes throughout the world in all age groups, resulting in reduced physical activity and increased energy intake (Ignjatovic & Cvecka, 2017). In the structure of this „new morbidity“ of yound populations in modern communities, in addition to the abuse of psychoactive substances, reproductive health disorders, injuries and violence, obesity represents the leading cause of disease in adolescents (Radovanović, 2014). In early childhood, body mass index is physiologically reduced up to the age of four or five years, and then starts growing , continuing well into adolescence. This repeated increase of body mass index is termed „adiposity rebound“. In several studies, the increased risk of adult obesity has been described in individuals in whom the adiposity rebound occurred at an earlier age than usual (Rolland-Cachera & Péneau, 2013).

The trend of reduced physical activity, termed as an epidemic of sedentary lifestyle, is present in most developed countries. Low level of physical activity and sedentary behavior are the leading epidemiological factors in a variety of serious chronic diseases and one of the main causes of the so called obesity epidemic, among both the adult and young people(WHO, 2014). Obesity is one of the most conspicuous health issues in children. Worldwide, almost a third of children and adolescents have problems being overweight and obese (WHO, 2017). The most recent global data show that 18% of children and adolescents aged 5 to 19 years have problems being overweight or obese (WHO, 2017). The levels of daily physical activity in the young are progressively lower throughout the world. An insufficient level of physical activity has been identified as one of the leading causes of death globally, and one of the leading risk factors for a number of chronic diseases (WHO, 2014).

SECULAR TREND OF PHYSICAL ABILITY IN CHILDREN AND ADOLESCENTS

A secular trend or secular change in anthropology denotes the process leading to gradual change of average physical measurements of the human body from generation to generation. Secular trends indicate a dramatic drop in physical abilities in children of all ages. The problem is ubiquitous, but the European Union (EU) countries have performed most of the studies. Ten years ago, the EU published the recommendations concerning physical activity in children (EU Guidelines on Physical Activity, 2008), stressing the problem of physical inactivity and obesity. Official agencies and organizations of the EU have emphasized the problem in recent years as well, but the problem nevertheless continues to grow (EC Expert Group, 2015).

The indicants of muscle strength and cardiorespiratory endurance expressed related to body mass have shown a constant decreasing trend in younger populations in the last five decades. It was observed that well documented secular increases in body mass and body height and other anthropological parameters (especially body mass index – BMI) in the young were not accompanied by an appropriate increase in physical strength and cardiorespiratory endurance in everyday activities. Several studies and epidemiological research (Tudor-Locke, 2010; Ivanović & Gajević, 2015) have suggested that present day children and adolescents are not nearly as active as their peers several decades ago. Studies have revealed a constant reduction of the level of physical activity and organized engagement in sports in the community (Dollman, Norton, & Norton, 2005; Donnelly & Lambourne, 2011).

The muscle strength is regarded as a significant marker of health in children and adolescents, and different types of physical exercise, as a part of regular daily physical activity, are recommended for an adequate and well balanced growth and development of children. However, there is an apparent trend of reduction of motor ability in children and adolescents observed in children in England, Netherlands, Spain, Lithuania and Serbia (Cohen, 2011; Moliner-Urdiales 2010, Jurimae, 2007; Ignjatovic, 2017).

In the past several years, several studies were published (Ivanović & Gajević, 2015; Ignjatovic & Cvecka, 2017; Ignjatovic, Radovanovic & Marković, 2018) dealing with the topic of secular changes of anthropometric characteristics and motor ability of children and adolescents aged from 7 to 14 years in Serbia. In the study by Ignjatovic & Cvecka (2017), an increase of body mass of almost 40% was revealed in children aged 12 years (from 36.26 kg to 50.92 kg) in the observation period of 50 years. In the same period, the results of the tests for muscle strength assessment did not significantly change. In the study published earlier this year (Ignjatović, Radovanović & Marković, 2018), the measurement results from 1975 and 2014 were compared for girls and boys aged 11 and 13 years. The average body height in these children increased from 6 to 12 cm, while the average increase of body mass in girls was between 7 and 11 kg, and in boys between 8 and 13 kg. The observed increased in basic anthropometric measurements did not result in any increases in motoric tests – significantly poorer results were observed instead.

PRINCIPLES OF PHYSICAL ACTIVITY PLANNING IN CHILDREN AND ADOLESCENTS

The above secular trends of physical ability of children and adolescents represent a clear warning that all the necessary measures have to be undertaken to increase the level of physical activity of this population. Two main principles in the planning of physical activity of children should be (Radovanović & Ignjatović, 2013):

- Creation of positive early experience for children through various forms of physical activity; and
- Inclusion of physical activity into regular everyday life of children.

Later on in life, physical activity of adolescents takes place in the form of regular physical education in schools and active and recreational engagement in sports. During adolescence, physical activity has an important role in the physical, social and mental development of the young (Radovanović & Ignjatović, 2018). Engagement in sports or regular physical activity has both direct and indirect effects on the health of adolescents. Health-related benefits of physical activity are reduction of body mass and/or maintenance of desirable body mass, improvement of glycemia, improvement of values of serum cholesterol and other lipid profile parameters, blood pressure reduction, and so on (Kelley & Kelley, 2013).

Children and adolescents with excess weight or obesity are faced with numerous health-related and psychosocial risks. Excess weight acts as an excess load in moderate to high intensity aerobic physical exercise (for instance in running, or in ball sports), and additionally increases the risk of injury to the musculoskeletal system, commonly classified as overload syndromes (Smith, Eather, Morgan, Plotnikoff, Faigenbaum & Lubans, 2014). Furthermore, children and adolescents with excess body mass or obesity often perceive aerobic physical activity as an unpleasant or discomforting activity (Faigenbaum & Westcott, 2009).

Strength training is a type of physical exercise which enables this high health risk group to distinguish themselves, demonstrating potential physical and psychological health benefits in this population group (***Radovanović, 2017***). The results of numerous recent studies have been accompanied by the reports of leading international professional and health associations, suggesting that if organized and performed properly, strength training in children and adolescents can be beneficial (American Academy of Pediatrics Council on Sports Medicine and Fitness, 2008; Lloyd et al., 2014). The observed effects statistically significantly differ from the changes expected to occur only as the result of normal growth and development. During strength training, overweight or obese children and adolescents are not exposed to great aerobic demands, and due to the size of their body they can use greater masses of external burden (free dumbbells or exercise machine loads) compared to their peers, which enables them to distinguish themselves, to feel good exercising and to experience their personal progress (Faigenbaum & Westcott, 2009; Ten Hoor et al, 2016). Free dumbbells are the most commonly used loads in strength and muscle force training, as well as training machines, both standard ones and those specially designed for younger age groups (Faigenbaum, Lloyd, & Myer, 2013). Moreover, training programs for children and adolescents consist of exercises with medicine balls and expander sets or elastic bands (Ignjatovic, Markovic & Radovanovic, 2012).

CONCLUSION

Secular changes indicate a dramatic drop of physical ability in children of all ages. Promotion of healthy lifestyles with regular physical activity and adequate nutrition during childhood and adolescence, with prevention measures by professionals to reduce overweight or obesity, is essential for the future of human society and has huge economical, social and demographic implications for the future of each individual country. Regular physical activity should be an integral part of everyday life, in combination with proper nutrition. Primary and secondary schools and universities are probably the most appropriate places in the promotion of proper nutrition and patterns of physical activity, providing opportunities for the engagement of parents and broader community as well. Regular physical activity of children and adolescents, with the improvement of their nutrition, is an effective and rewarding investment into their future.

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POSTURAL DISORDERS OF ATHLETES WITH VISUAL IMPAIRMENT

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SUMMARY

Visual impairment, i.e. the lack of visual control can lead to postural disorders of the spine. Taking part in sports has positive effects on the development of motor skills, so it can be assumed that it also has positive effects on reducing the presence of postural disorders among athletes with visual impairment. With regard to this, the aim of this paper was to determinethe difference in the presence of postural disorders and body deformities between athletes with visual impairment and non-athletes from the same population. The sample of participants consists of 21 athletes and 20 non-athletes with visual impairment. For the assessment of postural disorders, a device called "Spinal Mouse" was used, with which 8 variables were determined. 52.39% of the athletes had some form of postural disorder, most of whom had bad scoliotic body posture combined with kyphosis and lordosis. 55% of the non-athletes had some form of postural disorder, where kyphosis was the most frequent one – 30%. There was no statistically significant difference in the presence of postural disorders of the spine between the two groups. Based on the obtained results, in this group of the participants it can be concluded that taking part in sports does not lead to a reduction in the presence of postural disorders among athletes with visual impairment compared to non-athletes from the same population.

Keywords: kyphosis, lordosis, scoliosis, blind persons

INTRODUCTION

The term posture represents the position that a body assumes (Đorđić, 2007), that is, is a descriptive term for the relative position of the segments of the body at rest or in motion (Demeši-Drljan & Mikov, 2012). Postural disorders include poor body posture which is characterized by a weakness of the entire body, especially the joint-muscle apparatus. In these states what is most pronounced is the static insufficiency of the spinal column, which is a consequence of the weakness in the other parts of the locomotor system (Živković, 2009). Scoliosis, kyphosis and lordosis are the most frequent postural disorders and body deformities of the spinal column. Furthermore, many combinations of thesedeformitiescan occur, such as kypho-lordosis, followed by kyphosis and scoliosis, lordosis and scoliosis (Milenković, 2007). Three systems influence the upright, standing position of humans, including the visual, vestibular and sensorimotor, which play an important role in sensory-motor integration during control of postural balance (Paulus, Straube & Brandt, 1987; Sousa, Silva & Tavares, 2012; Grace Gaerlan, Alpert, Cross, Louis & Kowalski, 2012). Grace Gaerlanet al. (2012), by comparing the abovementioned three sensor systems, indicated that the visual system is the main sensory system for establishing a standing posture. Visual impairment includes a partial or full absence of any discernment of light, or more significant damage to eyesight, with visual acuity in the better eye of 0.05 to 0.3 which with correction can even exceed 0.3 with a prognosis for further lack of visual control. The smallest number of blind and visually impaired individuals are usually children, while most afflicted individuals are over the age of 70 (Aleksandrović, Jorgić & Mirić, 2016).

Individuals with visual impairment taking part in sport can better develop their motor skills and improve their body composition compared to non-athletes from the same population. This is realized through technical, tactical and conditioning preparations, which, depending on the sport, develop certain motor skills such as strength, speed, flexibility, etc. (Karakaya, Aki & Ergun, 2009; Krzak, Ślężyńska & Ślężyński, 2015; Tulin & Merve, 2015; Biyikli, Güler, Kuruoğlu, Akgül, Çetinkaya & Boyaci, 2018). In order to maintain proper postural status, certain corrective gymnastics exercises are required, properly dosed physical activity, and taking part in sport. The **aim** of the paper is to determine the difference in the prevalence of postural disorders and physical deformities among visually impaired athletes and non-athletes from the same population.

METHODS

Participants

The sample of participants consisted of visually impaired men aged from 20 to 50 who were divided into two groups. The first group of 21 participants was made up of athletes. The second group of 20 participants was made up of non-athletes. When it comes to the level of visual impairment, the research included participants from all three sports classes, from B1 to B3. This means that the research included both blind and visually impaired participants.

Procedure

To evaluate any postural disorders, the "Spinal Mouse"device was used (Idiag, Fehraltdorf, Switzerland, www.idiag.ch). This device belongs to the group of non-invasive measuring instruments for the evaluation of postural status of the spinal column. Based on the measurements, the following variables for postural disorder were obtained:

1. No postural disorder (BPP);
2. Kyphotic posture (KIFO);
3. Lordotic posture (LORD);
4. Kypho-lordosis (KILO);
5. Scoliosis (SKO);
6. Presence of all three forms of poor posture (KLS);
7. Kyphotic and scoliotic posture (KS);
8. Lordotic and scoliotic posture (LS).

The"Spinal mouse"device has already been used in other studies (Jorgić, Milenković, Ždrale, Milenković, Stanković & Bubanj, 2015; Jorgić, Đorđević, Belomazeva, Milenković, Tsonkova, Georgiev & Kostić, 2016). Several studies have confirmed the validity and reliability of this manner of measuring postural disorders (Mannion, Knecht, Balaban, Dvorak & Grob, 2004; Post & Leferink, 2004).

Statistical analysis

All of the obtained results were presented as the frequencies, that is,frequency of the results in absolute values and percentages. To determine the differences in the prevalence (frequency) of postural disorders and physical deformities between the two groups of participants, the Chi-square test of independence was used. To determine the differences in the prevalence of postural disorders within each individual group of participants, the Chi-square test for goodness of fit was used. The data were processed using the statistical program IBM Corp. Released 2010. IBM SPSS Statistics for Windows, Version 19.0. Armonk, NY: IBM Corp.

RESULTS

Tables 1 and 2 show the results for the prevalence of postural disorders among athletes and non-athletes with visual impairment. Among the athletes, 52.39% have some form of postural disorder of the spinal column, in the frontal and sagittal plane. Among the non-athletes, 55% of them have some form of postural disorder of the spinal column. Studied individually, among the athletes the most prominent was the scoliotic posture in combination with kyphosis and lordosis. Among the non-athletes, the most prevalent was kyphosis with 30%.

Table 1: Prevalence of postural disorders among the athletes with visual impairment

Variables	N	%
BPP	10	47.61
KIFO	1	4.76
LORD	0	0
KILO	1	4.76
SKO	3	14.29
KLS	0	0
KS	3	14.29
LS	3	14.29
Total	21	100

Table 2: Prevalence of postural disorders among the non-athletes with visual impairment

Variables	N	%
BPP	9	45
KIFO	6	30
LORD	1	5
KILO	0	0
SKO	1	5
KLS	3	15
KS	0	0
LS	0	0
Total	20	100

The results shown in table 3 indicate that among the athletes with visual impairment, there is no statistically significant difference in the prevalence of postural disorders, that is, there is no significant difference in the number of athletes who have some form of postural disorder compared to those with no disorders of the spinal column (sig=0.827). The results shown in table 4, which refer to the non-athletes, also indicate that there is no statistically significant difference in the prevalence of postural disorders within the studied group (sig=0.655).

Table 3: The results of the Chi-square for goodness of fit for the group of athletes

Variable	Frequency	Percent	Chi-square test	
BPP	10	47.61	Chi-Square	0.048
DEF	11	52.39	df	1
Total	21	100	Asymp. Sig.	0.827

Table 4: The results of the Chi-square test for goodness of fit for the group of non-athletes

Variable	Frequency	Percent	Chi-square test	
BPP	9	45	Chi-Square	0.200
DEF	11	55	df	1
Total	20	100	Asymp. Sig.	0.655

Table 5. Cross-tabulation

		Groups		Total
		Athletes	Non-athletes	
BPP	Count	10	9	19
	% of Total	2.4%	22.0%	46.3%
DEF	Count	11	11	22
	% of Total	26.8%	26.8%	53.7%
Total	Count	21	20	41
	% of Total	51.2%	48.8%	100.0%

Table 5 shows the results of the cross-tabulation for the group of athletes and non-athletes with visual impairment.

The results shown in table 6 indicate that there is no statistically significant difference in the prevalence of postural disorders of the spinal column among the athletes and non-athletes with visual impairment (sig = ,867).

Table 6: The results of the Chi-square test of independence

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	0.028a	1	0.867
Continuity Correction	0.000	1	1.000
Likelihood Ratio	0.028	1	0.866

DISCUSSION

The results of this research indicate that in the studied group of visually impaired individuals, the prevalence of postural disorders was greater than 50%, or more precisely was 53.7%. Viewed individually as groups, among the visually impaired athletes the prevalence of postural disorders was 52.39%. Viewed individually, among the visually impaired athletes the most prevalent disorder was scoliosis14.29%, and a combination of postural disorders of kyphosis and scoliosis 14.29%,and lordosis and scoliosis, also with 14.29%. In addition, the prevalence of kyphosis was 4.76% and kypho-lordosis was also 4.76%. For the studied group of non-athletes with visual impairment, 55% of them had some form of postural disorder of the spinal column. The most prevalent were kyphosis with 30%, followed by a combination of all three postural disorders (kyphosis, lordosis and scoliosis) with 15%, lordosis with 5%,as well as scoliosis with 5%. These results and those presented in tables 3 and 4 indicate that there is no statistically significant difference in the number of participants with postural disorders and those without for both groups of participants.

We can note that among the athletes with visual impairment, the most prevalent is scoliosis, followed by a combination of scoliosis and kyphosis and lordosis. The explanation for these results could be the specific nature of the sport in which most of the participating athletes took part, which is goalball.In goalball the ball is thrown toward the opponent's goal with one hand, and the technique most closely resemblesthat of the shot put. When preparing to throw the ball, as well as during the throw itself, the player is bent forward and to the side of the hand performing the throw, which might lead to the occurrence of the aforementioned postural disorders. Among the non-athletes, the most prevalent form of disorder was kyphosis. The explanation for this resultis the body position that visually impaired individuals assume when walking. Based on the extensive study of Alotaibi et al. (2016), individuals with visual impairment, due to the lack of visual control when walking, compensate with their whole body, which is among other things reflected in their stooped posture, head which is pulled back into their shoulders and tilted forward, and the onset of kyphosis. These findings are borne out by the results of the research of Amouzadeh Khalili et al. (2012) in which kyphosis was the most prevalent postural disorders among blind female participants. In the research carried out by Narvila et al. (2014), which included 28 participants with visual impairment, kyphosis was also the most prevalent postural disorder.

In terms of differences in the prevalence of postural disorders between the group of athletes and non-athletes with visual impairment, no statistically significant difference was noted (sig=0.867). In the research of Bolach et al. (2000) no significant difference was determined in the prevalence of the deformity in the sagittal plane, while in the frontal plane, athletes with visual impairment had a significantly less frequent prevalence of scoliosis. The obtained data in our and the mentioned studies still cannot fully be compared based onthe differences in how the postural status was determined. Due to the small number of studies which includeathletes with visual impairment, we also took into consideration research carried out on athletes without visual impairment. By analyzing a greater number of studies, Schiller & Eberson (2008) determined that in certain sports, such as gymnastics and rhythmic gymnastics, female athletes had greater values for kyphosis and lordosis compared to the non-athletes. When it comes to female handball players, the obtained results cannot be directly compared to the results of our research, considering that these are different kinds of sport, but they do support the results of our research which indicate that takingpartin sport does not necessarily mean better postural status. In order to generalize the obtained results, it is necessary to more precisely define the sample of participants, in the sense of determining their competitive level and the extent of their visual impairment. What has been confirmed in this study in comparison to previous ones is that there is a great prevalence of postural disorders among individuals with visual impairment. As a result, corrective exercise for postural deformities should be an integral part of their weekly physical activities.

CONCLUSION

Based on the obtained results, it could be concluded that there is no statistically significant greater prevalence of postural disorders among the non-athletes with visual impairment compared to athletes from the same population, that is, there is no statistically significant link between taking part in sports and postural disorders among blind individuals.

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RELATIONSHIP OF AEROBIC ABILITIES AND AGILITY WITH MILITARY PHYSICAL TASKS IN THE SERBIAN ARMED FORCES

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SUMMARY

The level of physical ability of professional military personnel (PMP) is checked by applying different tests to assess motor and functional abilities, but there is little research that has confirmed their applicative value. The purpose of this study was to determine the relationship of aerobic ability and agility with the military readiness obstacle course (MSKILL). The study was conducted on 17 male subjects, 27.71 ± 7 years old, of PMP in the Serbian Armed Forces (SAF). In the research were applied tests for the aerobic ability and agility assignment. Statistica 8.0 was used for data processing. The results have shown a statistically significant relationship between aerobic ability and agility with MSKILL ($R = 0.840$, and 0.884; $R^2 = 0.706$, and 0.782, $p < 0.05$). Agility T-Test and absolute VO_2max have an excellent correlation with MSKILL ($r = 0.86$, and -0.83, $p < 0.05$). These tests may be the basis for constructing a set of tests to assess military physical tasks.

Keywords: agility, aerobic capacity, military, soldier readiness, obstacle course

INTRODUCTION

Military personnel on professional and combat tasks often have difficult tasks, such as recurring lifting, carrying heavy goods over long distances, and realizing a rapid execution of combat maneuvers through combat surroundings (Sharp, Patton, & Vogel, 1998). In most countries in the world, the level of physical fitness of military personnel is checked by applying different tests (Deakin et al., 2000; Rayson, Holliman, & Belyavin, 2000; Ministry of Defence, 2011; Army, 2012; Australian Defence Force, 2018). The purpose of these check-ups is to confirm personnel's physical abilities to perform various tasks within an assigned mission of a respective military organization. The manual for military physical readiness, which defines standards for assessing an individual's physical abilities has been put into practice in SAF since 2011 (Ministry of Defence, 2011). Military physical readiness includes a set of tests to estimate the repetitive strength of the muscles of the arm, shoulder and abdomen, aerobic fitness tests, and a specially designed military obtsacle course (Ministry of Defence, 2011).

Different sets of tests for military physical readiness have been constructed in countries around the world (Ministry of Defence, 2011; Army, 2012; Australian Defence Force, 2018). All these tests are easy to apply and serve to assess handling heavy materials, such as maximum lifting, repetitive lifting, carrying, military lifting and carrying and / or digging. These sets of tests assess strength, explosive strength - horizontal jumps (Bilzon, Scarpello, Bilzon, & Allsopp, 2002; Harman et al., 2008), long jumps (Foulis et al., 2017); repetitive strength - push-ups and curls (Rayson, Holliman, & Belyavin, 2000; Ministry of Defence, 2011; Army, 2012; Australian Defence Force, 2018), lifting squats (Foulis et al., 2017); static strength - isometric strength of upper arms (Myers, Gebhardt, Crump, & Fleishman, 1984; Rayson, & Holliman, 1995), hand-grip test (Myers et al, 1984; Rayson et al., 2000), and pulling boxes (Carstairs, Ham, Savage, Best, Beck, & Doyle, 2016). On the other hand, besides lifting and carrying loads, one of the important tasks is rapid and endurance movement through a battlefield. In this regard, sets of tests also include agility tests - "Shuttle Run" (Australian Defence Force, 2018), „Illinois Agility Test", „T-Test", and „Edgren Side Step Test" (Kraemer et al., 1998; Raya et al., 2013); anaerobic ability tests - „Beep Test" (Bilzon et al., 2002); aerobic abilities tests - 2400 m and 3200 m runs (Army, 2012; Foulis et al., 2017; Australian

Defence Force, 2018). There are just a few studies that have confirmed the applicative value of using these tests to assess the level of physical abilities required to predict military ability (Stevenson et al., 1992; Sharp et al., 1993; Pandorf et al., 2003). Deakin et al. (2000) found that tests used to estimate repetitive strength and endurance in SAF and the United States (USA) do not have a high significiant correlation with the prediction of military ability. Research by Foulis et al. (2017) also showed that tests constructed in such a way do not have a high statistical prediction.

A certain test for military physical ability has been applied in the SAF. MSKILL is designed to simulate crossing the battlefield with diverse obstacles (Ministry of Defence, 2011). Newcomers in the SAF, as well as PMP up to 32 years of age, are expected to justify their physical ability on such a constructed test. Since, due to its complexity, obstacle course is not present in admission for SAF, nor is it included in physical military readiness of PMP older than 32 years of age, it is necessary to further investigate which motor skills and tests relate to MSKILL, construct easy-to-use sets of tests which will be a good predictor in selection, monitoring of the physical ability level and designing of training programs.

Based on the above mentioned, the purpose of this study is to determine the predictive models of the time scored on the military readiness obstacle course by determining aerobic ability and agility of PMP in SAF.

METHODS

Subjects

The study included 17 PMP of SAF, aged 25 to 32. The mean values (SD) of their age, body weight, height and BMI were 27.71 ± 7 years, 85.94 ± 33 kg, 1.82 ± 0.17 cm and 25.86 ± 8.60. kg·m^{-2}. All military personnel were qualified for their occupations in their units, with a minimum job tenure of three years in SAF. Their physical readiness varied from the work required physical exercise to leisure physical activities. All participants were given a consent to perform necessary measurements, after which they were subjected to a medical examination to obtain confirmation that they are physically capable to perform necessary motor tasks during the examination. Military personnel who have been identified with immediate or acute injuries, as well as other illnesses, were excluded from the research. Participants were given instructions to continue to apply their regular every day exercise routine during the duration of the research. Prior to the start of the research, the participants were familiar with the Security and Health Protection at Work prescribed by the Sports Regulation in SAF (Ministry of Defence, 2011). The commandmant of the 126.brVOJIN unit approved the research in this unit.

Procedure

The measurements were made in the period from March to June 2018 at the sports fields of the respective unit. All the measurements were carried out by pre-trained persons, i.e. professors of physical education. On the first day of the survey, participants were introduced with the test procedure in detail, and then they approached to the measurements of anthropometric characteristics. On the second day of the survey, participants approached the measurement of motor skills. The tests for the assessment of agility were carried out first, followed by the tests for the assessment of aerobic ability. On the third day, participants were tested on the military obstacles course (Ministry of Defence, 2011). During the research, participants carried sports equipment for measuring motor skills and camouflage uniforms M-10 with boots used for military training. Each day of testing began with warming-up, instructions, and description of exercises on testing.

Outcome measures

Body height (HIGHT) was measured with an accuracy of 0.1 cm using a standardized anthropometric instrumentarium (GPM, Switzerland). The body mass (MASS) was measured with an accuracy of 0.1 kg on a standardized digital balance (Beurer BF 66). Based on the obtained results of body height and mass, BMI was calculated using a standardized formula kg·m^{-2}

Motor Abilities Tests

(1) Tests for the assessment of aerobic ability.

4. 2400 m run (T2400). On the command “go”, the participants that stood behind the start line had to run 2400 m as fast as they could to the end of the track. Walking was allowed during testing. The time required to complete the test was measured in seconds (Ministry of Defence, 2011).

5. Absolute VO_2max (VO2MAXA). It was calculated for each participant based on the time taken on the 2400 m run test using the following formula: VO_2maxA = (483 / time) + 3.5. (Wood, 2008)

6. Relative VO_2max (VO2MAXR). It was calculated based on the VO_2maxA value using the following formula: VO_2maxR = VO_2maxA x 1000 / kg. (Bryant, & Green, 2010)

(2) Tests for Agility Assessment.

4. „10 m Agility Shuttle Test“ (SHUTTLE). On the command "go", the participants’ task was to run as fast as they could to the opposite line, raise

the "relay", return to the start line and lower it to or out of the starting line, then turn without rest, go back to the opposite line in order to take the second "relay" and transfer it over the finish line. The time required to complete the test was measured in seconds. The participants had the right to repeat the section twice. The fastest test time was taken as a final result. Attempts with a throw-in or drop-off of the "relay" were not counted as valid (Wood, 2008).

5. „Agility T-Test“ (T-TEST). On the command "go", the participants started moving forward as quickly as possible to the centre cone, sidestepped to the right 5 m to the right cone, sidestepped to the left 10 m to the far left cone, and then sidesstepped back to the right to the centre cone. The participants then moved backward as quickly as possible to cross the finish line. The time required to complete the test was measured in seconds. The participants had the right to repeat the section twice. The fastest test time was taken as a final result. In cases where participants failed to run the course as instructed, disqualification was determined (Raya et al., 2013).

6. „30 s Endurance Jump“ (RJUMP). The participants were standing on one side of the 30 cm high obstacle. On the command "go", the participants started jumping over the obstacle sidestepped on one side (for example, to the right) and then returned the same way. This was a complete cycle. The participants' task was to complete as many cycles as possible in one minute. Incorrectly performed cycles were not counted. One complete cycle was counted as 1, and half a cycle as 0.5. The result wass expressed as a repetition rate in one minute (Wood, 2008).

A Military readiness obstacle course

MSKILL is designed to simulate crossing a battlefield with scattered obstacles. It is composed of 18 different obstacles arranged on a 240 m long section. Obstacles: wire mesh, a fence made of undergrowth, palisades, logs, two beams, scaffolding, horizontal ladders, a wire fence, a shaft, combined ladders, three beams, holes, doors and windows, a tunnel, horns, a corridor, sloping palisades, a trench. The initial position of the participants was foreground lying. On the command "go", the participants had to overcome the obstacles as fast as they could. Walking was allowed during testing. The time required to complete the test was measured in seconds. The participants had the right to repeat the section twice. In cases where participants failed to run the course as instructed, disqualification was determined (Ministry of Defence, 2011).

Statistical analysis

Descriptive data were calculated for anthropometrics and motor abilities. The results are presented by mean ± standard deviation (SD). The Pirson coefficient of correlation was used to determine the relationship between the predictor and the criterion variables (one with each of them). The values of this coefficient range from -1 to +1. The regression analysis was used to determine the impact of agility and aerobic ability on military readiness course. Statistical analyses were conducted in Statistica 8.0. The level of statistical significance was taken for $p < 0.05$.

RESULTS

Table 1 shows basic statistical parameters of the general indicators of the sample. By analyzing them, it was found that the participants' included in this study was average aged 28 (27.71 ± 7.00), body height 182 cm (1.82 ± 0.17), body weight 86 kg (85.94 ± 33.00), and BMI 26 (25.86 ± 8.60).

Table 1. Basic statistical parameters - general indicators of the sample

Variables	**N**	**Mean**	**Min**	**Max**	**Range**	**SD**
YEAR	17	27.71	25.00	32.00	7.00	2.592
HIGHT	17	1.82	1.76	1.93	0.17	0.050
MASS	17	85.94	68.00	101.00	33.00	9.562
BMI	17	25.86	21.60	30.20	8.60	2.571

By analyzing Table 2 in which basic statistical parameters of agility and aerobic ability of PMP are shown, it can be seen that these tests showed a slightly lower variability. This can be explained by the participants' lack of motivation to carry out the tasks. By screening the result, a normal symmetry of distribution around the arithmetic mean can be seen in almost all motorics tests. T-TEST is on the limit, while T2400 is more right-oriented which means that the test was relatively easy for this group of subjects. Kurtosis indicates that the results in all variables are in normal distribution. The results of T2400 and REJUMP are mildly compressed, while in SHUTTLE are slightly spread out.

By inspecting basic statistical parameters of MSKILL, it can be noticed that the results have an excellent discrimination. The best time scored on MSKILL is 86 s, while the weakest is 230 s. By screening the results, the distribution of data around the arithmetic mean is symmetric, and the results are in normal distribution.

Table 2. Basic statistical parameters of predictor variables and criterion variables

Variables	N	Mean	Min	Max	Range	SD	Error	Skew	Kurt
VO2MAXR	17	50.12	41.50	64.30	22.80	6.393	1.551	0.472	-0.161
VO2MAXA	17	4.25	4.04	4.37	0.33	0.088	0.021	-0.893	0.503
T2400	17	650.06	558.00	880.00	322.00	83.968	20.365	1.437	2.284
SHUTTLE	17	10.81	9.60	12.13	2.53	0.881	0.214	0.523	-1.356
T-TEST	17	10.60	9.66	12.10	2.44	0.859	0.208	1.030	-0.462
REJUMP	17	51.00	28.00	66.00	38.00	8.448	2.049	-0.977	2.758
MSKILL	17	160.12	86.00	230.00	144.00	36.662	8.892	0.446	0.643

Table 3 shows intercorrelations of the variables for assessing the aerobic capacity and MISKILL with the help of Pirson's correlation coefficient. By its inspection, it can be noticed that VO2MAXA and VO2MAXR are positive, and that all the variables statistically correlate significantly with each other. The highest coefficient of the correlation is between T2400 and VO2MAXA ($r = 0.99$, $p < 0.05$), and the weakest is between T2400 and VO2MAXR ($r = 0.64$, $p < 0.05$).

By analyzing the intercorrelation variables for assessing aerobic capacity and MSKILL, it is noted that all the coefficients are statistically significant and that VO2MAXR and VO2MAXA are negative, while T2400 is positive. The highest coefficient of correlation with the criterion variable has VO2MAXA ($r = -0.83$, $p < 0.05$), slightly weaker T2400 ($r = 0.81$, $p < 0.05$) and the weakest VO2MAXR variable ($r = -0.68$, $p < 0.05$).

Table 3. Intercorrelations of variables for the assessment of aerobic ability and MSKILL

Variables	VO2MAXR	VO2MAXA	T2400	MSKILL
VO2MAXR	1.00			
VO2MAXA	0.70	1.00		
T2400	-0.64	-0.99	1.00	
MSKILL	-0.68	-0.83	0.81	1.00

Table 4. Intercorelations of variables for the assessment of agility and MSKILL

Variables	REJUMP	SHUTTLE	T-TEST	MSKILL
REJUMP	1.00			
SHUTTLE	-0.79	1.00		
T-TEST	-0.78	0.90	1.00	
MSKILL	-0.80	0.81	0.86	1.00

Table 4 shows the intercorrelations of the variables for assessing the agility and MSKILL. It can be noted that T-TEST and SHUTTLE are positive and that all variables correlate significantly with each other. The highest coefficient of the correlation is between T-TEST and SHUTTLE ($r = 0.90$, $p < 0.05$), and the weakest is between T-TEST and REJUMP ($r = 0.78$, $p < 0.05$).

By analyzing the intercorrelation of the variables for assessing the agility and MSKILL, it is noted that all the coefficients are statistically significant and that SHUTTLE and T-TEST are positive, while REJUMP is negative. The highest coefficient of correlation with the criterion variable has T-TEST ($r = 0.86$, $p < 0.05$), slightly weaker SHUTTLE ($r = 0.81$, $p < 0.05$) and REJUMP ($r = -0.80$, $p < 0.05$).

By analyzing these intercorrelation variables for assessing aerobic ability and agility and MSKILL, it can be assumed that T-TEST ($r = 0.86$, $p < 0.05$) plays a major role in the predictions of MSKILL, and then VO2MAXA ($r = -0.83$, $p < 0.05$).

In accordance with the objective and tasks of the research, the regression analysis will show the proportion between the aerobic ability and MSKILL, and agility and MSKILL, and to what extent aerobic ability and agility can influence achieving better time on MSKILL.

Variables	r	Part - r	b	Std.Err. - of b	t(13)	p-value
Table 5. Regression analysis of MSKILL using the aerobic ability system						
VO2MAXR	-0.68	-0.204	-1.079	1.437	-0.750	0.466
VO2MAXA	-0.83	-0.153	-325.931	584.709	-0.557	0.587
T2400	0.81	-0.018	-0.038	0.569	-0.066	0.948
R = 0.840	**R^2 = 0.706**	**F(3,13) = 10.391**				**p < 0.00092**
Table 6. Regression analysis of MSKILL using the agility system						
REJUMP	-0.80	-0.379	-1.402	0.950	-1.476	0.164
SHUTTLE	0.81	-0.006	-0.264	13.282	-0.020	0.984
T-TEST	0.86	0.486	26.297	13.106	2.007	0.066
R = 0.884	**R^2 = 0.782**	**F(3,13) = 15.566**				**p < 0.00014**

The relationship between the overall system of aerobic ability and MSKILL was 0.84 (R = 0.840; R^2 = 0.706, $p < 0.05$). These results give a statistically significant explanation of the criterion variable by means of the aerobic ability system ($p < 0.00092$), so that it can be concluded that the aerobic capacity system has a statistically significant effect on military training.

By analyzing the individual regression coefficients, one can conclude that no coefficient is individually statistically significantly related to the criterion variable MSKILL.

The relationship between the overall agility system and MSKILL was 0.89 (R = 0.884; R^2 = 0.782, $p < 0.05$). These results give a statistically significant explanation of the criterion variable using the agility system ($p < 0.00014$), so it can be concluded that the agility system has a statistically significant effect on military training.

By analyzing individual regression coefficients, one can conclude that no coefficient is individually statistically significantly related to the criterion variable MSKILL. T-TEST showed individually the nearest boundary statistically significant in association with the criterion ($p < 0.066$).

DISCUSSION

The aim of this research is the development of predictive models of physical abilities necessary for solving tasks in the battlefield when performing military tasks.

This research includes tests for the assessment of aerobic ability and agility in order to determine their connection with the required military task in the SAF. T2400 was used to calculate the absolute and relative VO_2max. The high association between aerobic capacity and the criterion variable was (R^2 = 0.706, $p < 0.05$). All three tests have a very high correlation with the criterion variable, of which VO2MAXA has the highest (r = -0.83, $p < 0.05$), T2400 was slightly weaker (r = 0.81, $p < 0.05$), while VO2MAXR has shown moderate association with the criterion (r = - 0.68, $p < 0.05$). For predicting time on the obstacles, Jetté, Kimick, and Sidney (1989) have come to the conclusion that aerobic capacity is in relation with very long obstacles.

A set of agility-based tests chosen for this research do not require high financial needs and serve to assess different types of movement. SHUTTLE involves frontal movement and is good for estimating the speed of direction change, with multiple rotations turned on for 180 degrees. T-TEST includes frontal and sagittal movements that estimate the speed of the directional change when performing tasks by moving forward, backward and stepwise with four changes of direction. RJUMP involves sagittal movement and is good for estimating speed and the speed of the reaction.

The results of these agility tests show a high correlation with the military task (R^2 = 0.782, $p < 0.05$). All three tests have a very high association with the criterion variable, of which T-TEST has the highest (r = 0.86, $p < 0.05$), then SHUTTLE (r = 0.81, $p < 0.05$) and RJUMP (r = 0.80, $p < 0.05$). These results are in correlation with other studies (Raya et al., 2013) Australian Army has already included the Shuttle Run test in its set of tests for selection of candidates for military service (Australian Defence Force, 2018).

CONCLUSION

This research was concerned to determine the predictive models of the time scored on the military readiness obstacle course in order to implement them in the selection of persons for military service and to monitor physical abilities of those in service. Two sets of variables were selected for assessing aerobic ability and agility to determine their prediction in MSKILL. Both sets of variables showed a good prediction of military tasks (R = 0.840, and 0.884; R^2 = 0.706, and 0.782, $p < 0.05$).

The results showed that T-TEST and VO2MAXA (r = 0.86 and - 0.83, $p < 0.05$) can be highly efficient in identifying the right candidates for admission to the SAF, who will be able to master military training in order to save time and money needed to be trained with them. Also, by applying this easily applied physical readiness test with PMP, they can effectively monitor their level of physical abilities, while at the same time avoiding the possibility of getting injured.

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SIMPLE VISUAL REACTION TIME: DIFFERENCES IN RELATION TO GENDER AND LEVEL OF PHYSICAL ACTIVITY IN SERBIAN YOUNG ADULTS – PILOT STUDY

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SUMMARY

The aim of this paper is to define differences in simple visual reaction time (SVRT) related to gender and/or level of physical activity in Serbian young adults. The sample in this research consisted of a total of 168 subjects – mean age 23.77±6.28 years. The overall sample was divided into 8 subsamples in relation to gender and/or level of physical activity. In relation to the examined subsamples of men and women mean SVRT at the level of 198.33±19.07 and 190.59±15.23 ms was determined, respectively. In reference to the level of physical activity mean SVRT of 199.14±15.54 and 186.25±18.21 ms was determined in moderately and highly active subjects, respectively. Descriptive statistical analysis has shown that highly active men have shortest simple visual reaction time (178.4±18.03 ms), followed by highly active women (191.68±16.57 ms), moderately active men (195.82±10.26 ms) and moderately active women (203.07±19.47 ms). On the basis of the obtained results, it was determined that statistically significant mean SVRT differences exist in relation to gender (t=2.905, p=0.004) and level of physical activity (t=4.856, p=0.000). When considering the combination of these factors statistically significant differences (F=13.490, p=0.000) were determined on a general level, while significant partial differences (p<0.05) in SVRT were found between highly active men and all other groups, as well as between moderately and highly active women. The present study has established initial descriptive standards for SVRT in the population of physically active Serbian young adults. The results have shown the positive effect of physical exercise on SVRT, that can be considered a very important neuro-visual sensory characteristic, and confirmed previous findings that indicate differences in reaction time related to gender.

Keywords: reaction time, gender, physical activity, visual stimulus

INTRODUCTION

Reaction time can be defined as the time elapsed between the presentation of a sensory stimulus and the subsequent behavioral response (Shelton & Kumar, 2010). Although reaction time tasks are primarily used in psychology as a means to study mental processes and their underlying structures (Niemi & Naatanen, 1981), the importance of the ability to react quickly can be considered paramount in the context of everyday life and sports performance. The simple reaction time task, measures simple reaction time, general alertness and motor speed through a delivery of a known stimulus to a known location to elicit a known response ("CANTAB," n.d.), and can be considered a basic indicator of perceptual, cognitive and motor status of an individual. This most basic form of voluntary reaction mechanism has been extensively investigated, although using a variety of different methodologies and experimental approaches. Previous research has shown that significant differences in simple visual reaction time exist in relation to several important factors such as age, intelligence, practice, type of stimulus etc. (Ando, Kida, & Oda, 2002, 2004; Der & Deary, 2006; Fontani, Lodi, Felici, Migliorini, & Corradeschi, 2006; Jevas & Yan, 2001; Nettelbeck, 1980; Welford, 1977).

Although acute effects of physical training on reaction time have been extensively investigated, the findings on the matter are somewhat inconclusive (Collardeau, Brisswalter, & Audiffren, 2001; Nakamoto & Mori, 2008; Welford, 1980). Furthermore, there is a general lack of consistent data considering the long-term effects of periodical and permanent physical exercise on reaction time, probably due to the aforementioned methodological issues. Contrary to the previous, differences in reaction time in relation to gender have been well established. Research on the matter indicates that men have significantly shorter simple visual reaction time compared to women (Dane & Erzurumluoglu, 2003; Der & Deary, 2006; Milošević, 2002). However, a fairly recent paper by Silverman (2006) indicates a trend of an equation in reaction time between men and women. Although choice reactions are underpinned by more complex decision making (Schmidt & Lee, 1998) it seems that the same applies to this more common type of human behavior.

In reference to the previous and considering the fact that reaction time is an indirect index of the processing capability of the central nervous system and a simple means of determining sensory-motor association and performance of an individual (Das, Gandhi, & Modal, 1997) it is necessary to provide more recent and more relevant data on the matter. The aim of this paper is to determine simple visual reaction time differences related to gender and/or level of physical activity in highly and moderately active subjects, thus widening the fundus of scientific knowledge in this area closely related to sports performance and everyday activities.

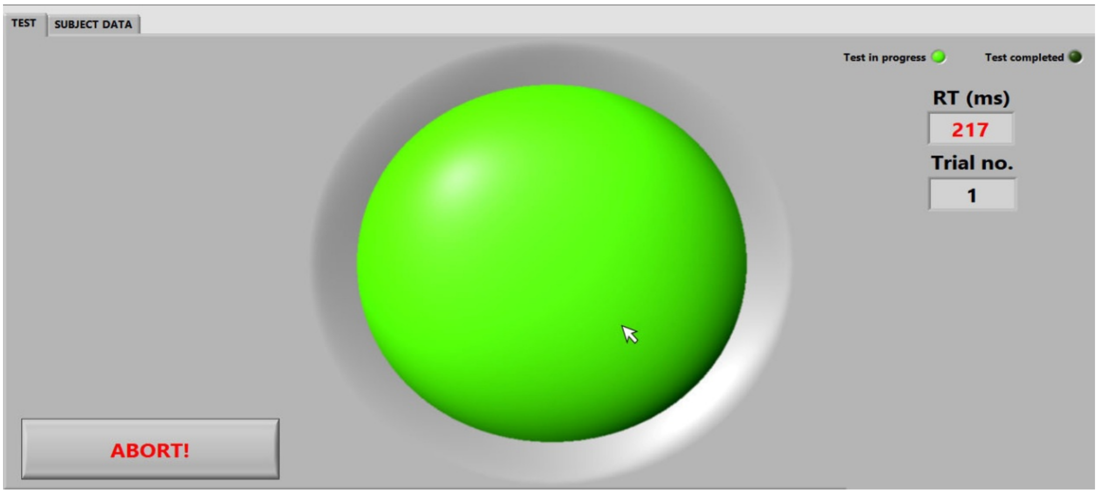
METHODS

The method used in this research was laboratory testing. All data sampling was performed using specially designed testing software that recorded reaction time with 1 ms precision and was developed in Labview 2012 software surroundings.

Procedure

Before participating in this research, all subjects were informed in detail about the measurement procedures and the possible risks and benefits of this research. All subjects read and signed an informed consent form. The study was conducted in accordance with the postulates of the Declaration of Helsinki and was approved by the Ethics Committee of the University of Belgrade Faculty of Sport and Physical Education. All tests were performed in the morning hours, between 9:00 and 11:30 AM. The procedure was explained and demonstrated to all subjects, who were then further familiarized with the testing procedure and equipment by performing two trial attempts. The test consisted of 5 consecutive reactions separated by a randomized time interval. Subjects had to react on a visual stimulus (15 cm diameter green dot appeared on a gray background) by pressing the left mouse button with their index finger (Figure 1). Reaction time lower than 120 ms was discarded as an error, and was substituted by an additional trial. Subjects were instructed to avoid any strenuous physical activity prior to testing and did not perform any type of warm-up.

Figure 1. Screenshot of the software application used for the testing of SVRT



Subjects

The sample in this research consisted of a total of 168 subjects – mean age 23.77±6.28 years. The overall sample was divided in relation to gender and/or level of physical activity in the following subsamples:

women – mean age 22.55±4.36 years, N=84; Men – mean age 24.99±7.57 years, N=84; Highly active (men and Women) – mean age 26.16±7.46 years, N=61; Moderately active (men and women) – mean age 22.40±5.04 years, N=107; Highly active men – mean age 29.04±9.08 years, N=26; Moderately active men – mean age 23.17±6.04 years, N=58; Highly active women – mean age

24.03±5.17 years, N=35; Moderately active women – mean age 21.49±3.35 years, N=49;

Subjects in highly active groups were national level athletes (track and field, volleyball and judo) and students of University of Belgrade, Faculty of Sport and Physical Education engaged in regular training for at least 300 min/week. Subjects in the moderately active groups were officers of Serbian Police force and students of Academy of Criminalistic and Police Studies (ACPS) in Belgrade and were engaged in physical training in accordance with the job requirements and requirements of the study program, i.e. 150-200 min/week. All subjects were healthy, had good vision, and were right-handed.

Variables

The variable used in this research, i.e. Simple Visual Reaction Time (SVRT) was calculated as a mean of 3 trials with the shortest Reaction Time. The achieved result was expressed in ms.

Statistical analysis

For the purposes of this paper, all raw data was subjected to descriptive statistical analysis in order to define the basic measure of central tendency (Mean), indicators of data dispersion – Standard deviation (SD) and Coefficient of variation (cV%), and results span indicators – Minimum (Min.) and Maximum (Max.). Normality of the distribution of the results was determined by application of the Shapiro-Wilk test. Differences between groups in relation to gender and/or level of physical activity were determined using Independent samples t-test and Univariate analysis of variance (ANOVA) with subsequent post hoc tests - Bonferroni. All data analyses were conducted using statistical packages Microsoft Excel 2013 and IBM SPSS v23.

RESULTS

Table 1. Descriptive statistics for the Simple Visual Reaction Time variable in relation to gender and/or level of physical activity

Descriptive Statistics for Simple Visual Reaction Time (SVRT) variable								
Group	N	Mean (ms)	SD (ms)	cV %	Min. (ms)	Max. (ms)	S-W	Sig.
Women	84	198.33	19.07	9.62	158.33	240.33	0.981	0.260
Men	84	190.59	15.23	7.99	145.67	223.67	0.975	0.103
Moderately active	107	199.14	15.54	7.80	158.33	240.33	0.983	0.191
Highly active	61	186.25	18.21	9.78	145.67	225.33	0.991	0.938
Highly active women	35	191.68	16.57	8.65	159.33	225.33	0.987	0.942
Highly active men	26	178.94	18.03	10.08	145.67	223.67	0.983	0.929
Moderately active women	49	203.07	19.47	9.59	158.33	240.33	0.968	0.208
Moderately active men	58	195.82	10.26	5.24	177.67	218.33	0.961	0.059

Table 2. Results of the Independent samples t-test for equality of means in relation to gender/level physical activity

t-test for Equality of Means					
Gender	t	df	Sig.	Mean Difference	Std. Error Difference
Women - Men	2.905	158	0.004	7.734	2.663
Level of Physical Activity	t	df	Sig.	Mean Difference	Std. Error Difference
Moderate - High	4.856	166	0.000	12.894	2.656

Graph 1. Mean Simple Visual Reaction Time (SVRT) values in relation to gender/level of physical activity with a statistical significance of group differences

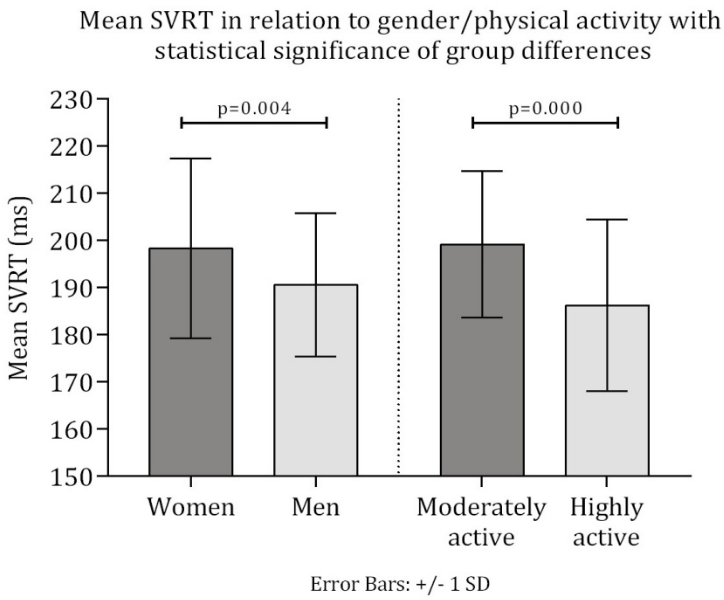


Table 3. Results of Univariate analysis of variance (ANOVA) with pairwise comparisons of different groups in relation to gender and level of physical activity

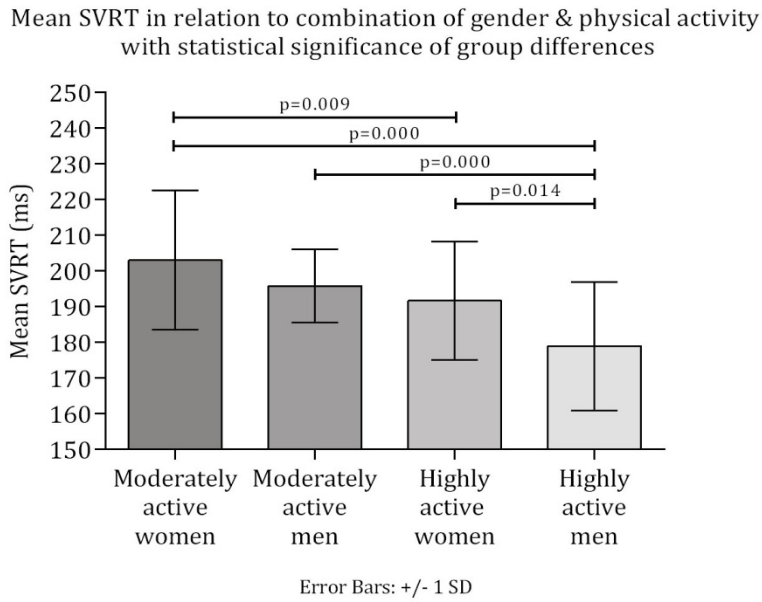
ANOVA				
Dependent Variable: SVRT	Mean Square	df	F	Sig.
	3426.796	3	13.490	0.000

Pairwise comparisons

Dependent Variable: SVRT

Group		Mean Difference	Std. Error	Sig.
Highly active women	Highly active men	12.740	4.126	0.014
	Moderately active women	-11.399	3.527	0.009
	Moderately active men	-4.140	3.411	1.000
Highly active men	Highly active women	-12.740	4.126	0.014
	Moderately active women	-24.139	3.867	0.000
	Moderately active men	-16.880	3.762	0.000
Moderately active women	Highly active women	11.399	3.527	0.009
	Highly active men	24.139	3.867	0.000
	Moderately active men	7.259	3.093	0.121
Moderately active men	Highly active women	4.140	3.411	1.000
	Highly active men	16.880	3.762	0.000
	Moderately active women	-7.259	3.093	0.121

Graph 2. Mean Simple Visual Reaction Time (SVRT) values in relation to the combination of gender and level of physical activity with a statistical significance of intergroup differences



DISCUSSION

Based on the results of descriptive statistical analysis it was determined that the coefficient of variation (cV %) of the obtained results ranges from 5.24% (Moderately active men) up to 10.08% (Highly active men). Results of the Shapiro-Wilk goodness of fit test have shown that there is no statistically significant deviation of the results in relation to the hypothetical normal curve for all samples included in this research, i.e. the obtained results are normally distributed ($p>0.05$). On the basis of the aforementioned, it can be argued that the obtained results have an extremely high level of homogeneity (Perić, 2003) and a normal distribution, which makes them representative in terms of further scientific processing and interpretation.

Results of the present research indicate that, when considering the overall sample, mean simple visual reaction time (SVRT) is 194.49±17.64 ms. Such a result is in line with the previous research that indicates that mean SVRT in humans is approximately 190-200 ms (Milošević, 2002; Silverman, 2006). This indicates a high level of external validity of software used for measurement of SVRT, on which basis it can be concluded that observed data can be used as valid for further discussion and scientific use.

In relation to the examined subsamples of men and women mean SVRT at the level of 198.33±19.07 and 190.59±15.23 ms was determined, respectively (Table 1). The results of an independent samples t-test have shown that apparent differences in relation to gender are statistically significant ($t=2.905$, $p=0.004$) (Table 2). These results are in line with the previous findings on the matter (Bleecker, Bola-Wilson, Agnew, & Meyers, 1987; Dane & Erzurumluoglu, 2003; Der & Deary, 2006) and further support the conclusion that men have shorter reaction times compared to women. In relation to the level of physical activity mean SVRT at the level of 199.14±15.54 and 186.25±18.21 ms was determined in moderately and highly active subjects, respectively (Table 1). An independent samples t-test has shown statistically significant differences ($t=4.856$, $p=0.000$) in SVRT in relation to the level of physical activity (Table 2). It should be noted that previously mentioned results are similar to those reported by Jyothi et al. (2016) who determined simple visual reaction time of 181.50±32.13 ms in runners and 269.3±46.80 ms in physically inactive controls. In reference to the previous, an interesting explanation for shorter reaction time in physically active subjects was proposed by Spirduso (1975) who points out to the possible positive relationship between augmented excitation and continuous demands for fast decision making during sports activities and enhanced neural efficiency. Mean SVRT values and differences in relation to gender or level of physical activity are shown on Graph 1.

Results of Univariate analysis of the variance (ANOVA) indicate that statistically significant differences exist in relation to the combination of age and level of physical activity ($F=13.490$, $p=0.000$) (Table 3). Descriptive statistical analysis has shown that highly active men have shortest simple visual reaction time (178.4±18.03 ms), followed by highly active women (191.68±16.57 ms), moderately active men (195.82±10.26 ms) and moderately active women (203.07±19.47 ms). Post hoc tests were applied in order to determine partial differences between individual samples. Statistically significant ($p<0.05$) differences in SVRT were found between highly active men and all other groups, as well as between highly and moderately active women (Table 3). These results clearly indicate a significant chronic effect of physical exercise, i.e. level of physical activity, on reaction time in both men and women. The mean SVRT values with intergroup differences are shown in Graph 2.

On the basis of all aforementioned, it can be concluded that the present study further confirms previous findings that indicate differences in reaction time related to gender, that is shorter SVRT found in men. Established differences in relation to the level of physical activity clearly indicate a positive effect of chronic adaptation to the requirements of sport and physical exercise on the function of the central nervous system, that is perceptual, cognitive and motor performance.

CONCLUSION

Results of the present research indicate that, when considering the overall sample (men and women), mean simple visual reaction time (SVRT) is 194.49±17.64 ms. In relation to the examined subsamples of men and women mean SVRT at the level of 198.33±19.07 and 190.59±15.23 ms was determined, respectively. The established difference between mean values indicates that women have 4.06% longer SVRT compared to men. Differences in SVRT in relation to gender are statistically significant ($t=2.905$, $p=0.004$). In relation to the level of physical activity mean SVRT at the level of 199.14±15.54 and 186.25±18.21 ms was determined in moderately and highly active subjects, respectively. When these values were compared percentage difference in SVRT of 6.92% was determined in favor of the highly active group. The established difference in relation to the level of physical activity was statistically significant ($t=4.856$, $p=0.000$). Descriptive statistical analysis has shown that highly active men have shortest simple visual reaction time (178.4±18.03 ms), followed by highly active women (191.68±16.57 ms), moderately active men (195.82±10.26 ms) and moderately active women (203.07±19.47 ms). Statistically significant differences in relation to gender and level of physical activity ($F=13.490$, $p=0.000$) were determined on a general level. Significant partial differences ($p<0.05$) in SVRT were found between highly active men and all other groups, as well as between moderately and highly active women. It was determined that highly active men have 7.12, 9.43 and 13.49% shorter SVRT when compared to highly active women, moderately active men and moderately active women, respectively. Also, a 5.95 % difference in SVRT was determined in favor of highly active compared to moderately active women.

The present study has confirmed previous findings that indicate differences in reaction time related to gender. Although further research on simple visual, as well as choice reaction time, is necessary this study has established differences in SVRT related to the level of physical activity, that is shorter SVRT in highly active subjects. This can be considered a positive effect of physical exercise on the function of the central nervous system, that is perceptual, cognitive and motor performance attributable to effects of augmented excitation and continuous demands for fast decision making during sports activities.

ACKNOWLEDGMENT

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THE RELATIONS BETWEEN FITNESS AND BMI AND THE ARTERIAL BLOOD PRESSURE OF ELDERLY MEN FROM AN URBAN ENVIRONMENT

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613.71/74-053.9

SUMMARY

The elderly population is constantly increasing in number, and the aging process carries with it a decrease in physical abilities, an increase in body mass and an increased risk of non-contagious diseases. This study was carried out with the aim of determining a connection between fitness and BMI and arterial blood pressure among men from an urban environment. The sample of participants included 414 men over the age of 65, living on the territory of the city of Nis. The set of predictor variables used to evaluate physical fitness consisted of the Senior Fitness Test and BMI. The criterion variables included systolic and diastolic blood pressure. The results of the study have shown that there is a statistically significant connection between fitness and BMI and systolic blood pressure ($p< .05$; $p= .005$). Based on the results, we can conclude that an increase in BMI among elderly men will result in an increase in systolic blood pressure. Also, elderly men with higher values of systolic blood pressure have lower cardiorespiratory fitness and decreased power of the lower extremities.

Keywords: fitness, BMI, arterial blood pressure, the elderly

INTRODUCTION

The increase in the human lifespan represents the greatest success of mankind, and is in part a consequence of the modern way of life, and progress made in the field of medicine. Based on the data provided by the United Nations, the number of individuals over the age of 60 has increased by 2% from 1950 to 2000 (from 8% to 10% of the overall population), and the prediction is that this number will rise to 22% of the overall population by 2050 (United Nations, 2005). Similar prognoses have also been made regarding the population of Serbia. Based on the last Census of Population, Households and Dwellings in the Republic of Serbia, individuals over the age of 65 make up 16,8% of the overall population, and this percentage will be as high as 22% by 2030, which means almost every fifth citizen (http://popis2011.stat.rs/).

Aging is a natural process which is connected to the loss of physical functions, vitality and functional fitness (Radovanović & Ignjatović, 2009; Shephard, 1997; Milanović, Pantelić & Jorgić, 2012; Rikli & Jones, 2001).

The level of functional fitness is often used as a parameter for monitoring and evaluating the health of the population and is almost always connected to one's health status. Results have shown that the level of functional fitness is significantly related to the weakening of functions necessary for the everyday life of males (Nagamatsu, Oida, Kitabatake, Kohno, Egawa, Nezu, & Arao, 2003).

Rikli & Jones (2001) define functional fitness as the abilities which are needed to perform daily activities in a safe and secure way, without any unnecessary fatigue or pain, which include components such as muscle power and the flexibility of the lower and upper extremities, aerobic endurance and motor agility/dynamic balance. The progressive decrease in muscle mass and power is dependent on age (Evans, 1995), and can have a negative influence on the performance of everyday activities (Rikli & Jones, 2001). Aging is also related to a decrease in flexibility (Dalei & Spinks, 2000).

Among the elderly, an increase in subcutaneous fat tissue occurs, which might increase the risk of the emergence of cardiovascular and respiratory illnesses (Milanović et al., 2012; Lee et al., 2007). Certain studies have determined that aging is connected to the progressive increase in arterial blood pressure, which begins in childhood and continues into adulthood (Franklin et al., 1997; Whelton, 1985). Franklin et al. (1997) noted a trend of greater increase in systolic blood pressure compared to diastolic blood pressure during mid-adulthood, which continues until the eighth or ninth decade.

A decrease in functional abilities (power, endurance, agility and flexibility) caused by the aging process, causes difficulties in everyday activities and the normal functioning of the elderly (Tuna et al., 2009). By increasing the level of functional fitness, we can achieve a physical, social and economic benefit for the elderly (Brill, 2004). Considering that the elderly are an important resource for their families and the economy, it is of great importance to determine the relations between the parameters of functional fitness and the body mass index on the one hand, and the parameters of arterial blood pressure on the other. A certain number of studies have focused on the connection between functional fitness, BMI and arterial blood pressure among women (Doll, Paccaud, Bovet, Burnier & Wietlisbach, 2002; Farrell, Braun, Barlow, Cheng & Blair, 2002; Kaur & Mogra, 2006; Kostić, Mladenović & Mikalački, 2007

Other studies which also focused on the connection between obesity, functional fitness and BMI and arterial blood pressure determined a connection between these parameters (Davy & Hall, 2004; Tesfaye et al., 2007; Peixoto, Benicio, Latorre & Jardim, 2006; MacAuley et al., 2006; Rhéaume et al., 2009; Droyvold, Midthjell, Nilsen & Holmen, 2005; Fagard, 2005).

Davy & Hall (2004) determined that there is a linear connection between obesity and arterial blood pressure, and that as many as 65 % of cases of hypertension among men and women have indirectly been caused by obesity. Similar results were obtained by Tesfaye et al. (2007), Peixoto et al. (2006) and Droyvold et al. (2005) who in their study reported an increase in systolic blood pressure of 4,9 mm/Hg among men who increased their body weight and became obese between two measurements (within a period of 11 years).

In a study by Levine, Calhoun, Prineas, Cushman, Howard & Howard (2011) it was determined that there is a connection between moderate waist circumference and the prevalence of hypertension, irrespective of BMI and several risk factors for hypertension .

The connection between cardiorespiratory fitness, body composition and the mortality rate was also studied by Sui et al. (2007). The level of cardiorespiratory fitness was evaluated by exercises of maximal intensity, while body composition, that is, the level of obesity, was evaluated based on the values of BMI, waist circumference and percentage of body fat. The research results led the researchers to the conclusion that a low level of physical fitness is a significant predictor of mortality among the elderly, irrespective of their overall or abdominal obesity.

Several studies, whose subject matter was the relationship between physical fitness and arterial blood pressure, determined that there is a significant negative correlation between these variables (MacAuley et al., 2006; Rheaume et al., 2009).

Even though all the mentioned studies indicate a strong cause-effect relationship between fitness and BMI on the one hand, and arterial blood pressure on the other, most of them included participants aged 20 to 65, and did not provide information on the nature of these relations after the age of 65. Thus, it is not quite clear whether the connection between these parameters among the elderly is still strong and significant, which imposes the need to study these relations further in detail.

The basic subject matter of this study are the characteristics of the connection between parameters of physical fitness and BMI and the parameters of arterial blood pressure among men over the age of 65. We propose that there are statistically significant relations between arterial blood pressure and the indicators of physical fitness and BMI. The aim of this study is to determine the structure, significance and characteristics of the relations between physical fitness and BMI on the one hand, and arterial blood pressure of elderly men on the other.

METHODS

Subjects

The sample of participants was selected from a population of elderly males, aged between 60 and 80, from the territory of the city of Nis (an urban population). A total of 414 participants (mean±SD aged 67,73 ± 6,61; body height 175,62 ± 9,78; body mass 82,26 ± 31,33), were included in the study. The criteria for participant selection were: ages between 60 and 80, physically independent individuals – able to take 20 steps without assistance or rest, a lack of any cognitive damage or dementia. The research was approved by the Ethics research committee of the Faculty of Sport and Physical Education, University of Nis, in accordance with the Helsinki declaration.

Procedure

The predictor group: this group consisted of 6 tests for the evaluation of physical fitness and BMI. In this study we used the tests from the Senior Fitness Test (SFT) battery: The 8-Foot Up-and-Go (agility/dynamic balance); The Back Scratch (shoulder mobility); The Chair Sit-and-Reach (lower body flexibility), The 2-Minute Step Test (cardiorespiratory fitness), The 30-Second Chair Stand (lower body power) and The Arm Curl (arm power) (Rikli & Jones 1999; Rikli & Jones, 2001). Body height was measured using an anthropometer, according to Martin (GPM Swiss Made). Body weight was measured on a digital scale TANITA UM-72 (Body Composition Monitor, Tanita Corp, Tokyo, Japan) to a precision of 0,01kg. To calculate BMI we used a standard procedure based on the formula BMI=Body weight [kg] / Body Height [m2] (WHO, 2000). The criterion group: This group consisted of systolic arterial blood pressure and diastolic arterial blood pressure. To evaluate blood pressure, the automatic digital reader OMRON M4-1 (OMRON Healthcare Europe BV, Netherlands) was used. The results were read as mm/Hg. The result of the measuring was the average value of the second and third measurement, based on the recommendation of the World Health Organization (WHO, 2005).

Statistical analysis

Descriptive statistics were calculated for all the data. The connection between the predictors and criteria were determined using the canonical-correlation analysis, with the help of the Statistica 7.0 program (StatSoft. Inc., Tulsa, OK, USA). The level of significance was .05.

RESULTS

Table 1 shows the parameters of descriptive statistics.

Table 1. Basic descriptive parameters (n=414)

	Means	**Std.Dev.**
Year	67,73	6,61
Height (cm)	175,62	9,78
Weight (kg)	82,26	31,33
BMI (kg/m^2)	27,04	13,88
Systolic blood pressure (mmHg)	133,08	14,85
Diastolic blood pressure (mmHg)	83,79	9,81
Back Scratch (cm)	-4,23	4,61
Chair Sit-and-Reach (cm)	0,61	10,16
8-Foot Up-and-Go (sec)	6,74	1,31
30-Second Chair Stand (broj)	13,90	5,56
Arm Curl (broj)	16,73	6,38
2-Minute Step Test (broj)	91,52	16,74

To determine the connection between the predictor and criterion group, a canonical correlation analysis was used.

Using the canonical correlation analysis to determine the relations between fitness (SFT), BMI and arterial blood pressure of elderly men, a statistically significant factor was isolated (p = .005) (Table 2). This canonical factor explains 4 % of the shared variability of the predictor and criterion variables. A statistically significant connection was determined between the sets of variables (p= .005).

Table 2. The canonical correlations between the predictors and the criteria of elderly men

	Canonicl R	Canonicl R^2	Chi-sqr.	df	p
0	0,19	0,04	31,18	14	.005
1	0,07	0,00	3,23	6	.780

Legend: Can.R- maximal correlation between the predictor and criterion variables; Can.R^2.- % of shared variability of the studied spaces; Chi-sqr- test of the statistical significance of the Can.R; Df- degrees of freedom; p- level of significance;

To determine the individual connections between the variables of physical fitness (SFT) and BMI as the predictors, and the values of systolic and diastolic blood pressure as the criterion, cross-correlations were calculated (Table 3). The obtained coefficients had low numeric values. For the sample of elderly men from an urban environment, systolic arterial blood pressure (SBP) showed the greatest correlation with BMI (0,12), while diastolic arterial blood pressure (DBP) showed no significant correlation with any of the predictor variables.

Table 3. The cross-correlation matrix

	Systolic blood pressure	**Diastolic blood pressure**
BMI	0,12	0,05
Back Scratch	-0,04	0,03
Chair Sit-and-Reach	0,02	0,04
8-Foot Up-and-Go	0,05	0,02
30-Second Chair Stand	0,06	0,03
Arm Curl	0,01	0,01
2-Minute Step Test	-0,09	-0,03

Table 4. The structure of the isolated canonical factors in the space of predictor and criterion variables

	Root 1	Root 2			Root 1	Root 2
BMI	-0,63	0,09		**Systolic blood pressure**	-0,99	0,17
Back Scratch	0,27	0,83		**Diastolic blood pressure**	-0,35	0,94
Chair Sit-and-Reach	-0,10	0,48				
8-Foot Up-and-Go	-0,24	0,09				
30-Second Chair Stand	-0,33	0,17				
Arm Curl	-0,04	0,19				
2-Minute Step Test	0,46	0,01				

By analyzing the structure of the first canonical factor in the space of the variables SFT and BMI (Table 4), we can note that the first canonical function can most be defined by: BMI (- 0,63) and the 2-Minute Step Test (0,46) and 30-Second Chair Stand (- 0,33). Thus, this factor can be defined as the factor of increased body mass, cardio-respiratory fitness and power of the lower body. In the structure of the first canonical factor in the space of arterial blood pressure, the obtained canonical function is most defined by systolic arterial blood pressure (- 0,99), which is why it can be defined as the factor of systolic blood pressure (Table 4).

DISCUSSION

A canonical correlation analysis was used to determine the significant relations between fitness and BMI and arterial blood pressure among elderly men from an urban environment.

Statistically significant relations were determined between fitness and BMI and systolic arterial blood pressure, while no significant relations were determined between fitness and BMI and arterial blood pressure.

The structure of the isolated canonical factor indicates that the factor of systolic arterial blood pressure is significantly related to the factor of body mass. Based on the sign of the coefficient, the connection between the isolated significant canonical factor of fitness and BMI and the first canonical factor from the system of variables for the evaluation of arterial blood pressure indicates that the studied men with increased body mass have higher values of systolic arterial blood pressure. A large number of studies have indicated that there is a significant connection between BMI and systolic arterial blood pressure (Pantelić et al., 2012; Doll, Paccaud, Bovet, Burnier & Wietlisbach, 2002; Matsumura et al., 2001; Kumar, Sudhir, Srinivasan & Punith, 2008; Huang et al., 2007; Amador, Al Snih, Markides & Goodwin, 2006). Doll et al. (2002) cite that an increase in BMI of 1,7 kg/m2 causes an increase in systolic blood pressure of 1 mm/Hg. These results are in agreement with those obtained by Đurašković (2009). Đurašković (2009) cites that with an increase in weight, that is, BMI, there is an increase in the length and number of capillary blood vessels, which places strain on the heart muscle. The obtained results can logically be explained: with an increase in body weight, that is, level of nourishment, the length and number of capillary blood vessels also increase, which places additional strain on the heart muscle, and leads to an increase in systolic arterial blood pressure (Đurašković, 2009).

The structure of the significant canonical factor from the system of variables of fitness and factors from the system of variables for the evaluation of arterial blood pressure indicates that a significant contribution in the explanation of systolic blood pressure is provided by parameters which are used to evaluate aerobic endurance and power of the lower body. Based on the sign of the coefficient, participants with higher values of systolic blood pressure have lower cardiorespiratory fitness and decreased power of the lower extremities. The obtained results are in accordance with the findings of previous studies (Kostić, Mladenović & Mikalački, 2007; Whelton, Chin, Hin & He, 2002; Stewart et al., 2005; Fagard, 2005). An explanation of this kind of connection between systolic blood pressure and cardiovascular fitness is based on the scientific claim that aerobic training decreases arterial blood pressure related to the decrease in systemic vascular resistance, which is caused by a decrease in sympathetic activity, and the decrease in the level of plasma renin activity and catecholamine (Cornelissen & Fagard, 2005). Furthermore, certain studies which also included a sample of elderly men have shown a significant connection between diastolic blood pressure and power and flexibility of the upper body (Pantelić et al., 2012).

During the aging process, there is a decrease both in the overall power, and the power of the lower extremities at the expense of a decrease in muscle mass. Lexell, Taylor & Sjöström (1988) indicate that during the aging process, especially after the age of 50, approximately 10 % of muscle fibers are lost. This kind of loss of muscle mass, with an increase in fat body mass, which is the result of inactivity, could lead to an increase in arterial blood pressure. Also, due to aging, there is a reduction in the activation of motor units (Radovanović & Ignjatović, 2009).

The results of this study indicate that there is a significant relation between BMI, muscle power, cardiorespiratory fitness and systolic blood pressure among elderly men from an urban environment. Based on the obtained results we could recommend that elderly individuals take part in power training and aerobic training, to improve their BMI and regulate their arterial blood pressure.

CONCLUSION

Based on the obtained results, we can conclude that there is a significant relation between BMI, cardiorespiratory fitness and power of the lower extremities and systolic arterial blood pressure of elderly men from an urban environment. In the study, no statistically significant connection was determined between the variables and diastolic blood pressure.

We can conclude that an increase in body mass in connected to an increase in systolic blood pressure, while an increase in the parameters of physical fitness negatively correlates with systolic blood pressure. Higher values of systolic blood pressure are connected to lower values of cardiorespiratory fitness and decreased muscle power of the lower extremities.

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THE INFLUENCE OF STRENGHT ON THE SPEED OF NAVIGATING AN INFANTRY TRAINING OBSTACLE COURSE

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SUMMARY

A high level of physical ability holds special importance for members of the Special Brigade. The level of physical abilities in a lot of ways influences success in performing many tasks, and thus increases the combat readiness of the unit. The aim of the research was to determine the role that power has on the speed of navigating an infantry obstacle course. The research sample included 98 participants. The participants were members of the 63rd Parachute Battalion of the Special Brigade of the Serbian Armed Forces(30±0,5 yrs). two groups of measuring instruments were used in the study: the first, predictor group, consisted of six parameters for the evaluation of muscle power, and the second, criterion group, consisted of a test for the evaluation of the fitness abilities used to evaluate navigating an infantry training obstacle course. To evaluate muscle power, the Myotest device was used. To determine the influence of certain parameters of power on the speed of navigating an obstacle course, a regression analysis was used. To process the data, the statistical package Statistica 7.0 was used. Based on the obtained results we can conclude that the set consisting of 6 independent variables which were included in the model explain 17,8% of the variance of the dependent variable, that is, the speed of navigating an obstacle course. This percentage of the explained variance is low, but is statistically significant (.006). Based on the obtained results we can conclude that the parameters of power have a significant influence on the speed of navigating an infantry training obstacle course, as well as that explosive power of the lower extremities yields the greatest influence..

Keywords: strenght, speed, infantry barriers

INTRODUCTION

The manifestation of muscle force is necessary for success in a great number of sports, and so we can conclude that athletes who are stronger and more powerful will have more success in disciplines which to a great extent depend on the ability to express muscle force. With an increase in muscle power, it is logical to expect an increase in the performance of motor tasks. The results of certain studies indicate that, in addition to anthropometric, functional abilities and psychological characteristics, motor abilities are also of great importance for achieving success in sport and physical education (Kasum, 2001; Karalejić & Jakovljević, 2008; Popović, 2010). Motor skills are of primary importance for solving sports tasks and are a precondition for the performance of complex forms of movement. The motor skills of individuals directly determine the success of performing physical activities (Nedeljković, 2007). Motor skills as an essential ability are included in equations for the specification of success in sport. Their role depends on the nature and complexity of the movement structure of a certain sport technique. A very pronounced role of motor skills lies in the manifestation and realization of athletic movement structures, such as racing, jumping and throwing disciplines, where it realized certain relations which are manifested through sport results or an evaluation of the success in performing a given movement technique (Pavlović & Radinović, 2010). Power represents one of the most widely studied motor skills. In literature there is a large number of definitions, divisions and methods for its development. Numerous authors have indicated that strength is defined as man's ability to use muscle contractions to overcome external resistance or to oppose it (Herodek, 2006; Stojiljković, 2003; Nićin, 2000; Malacko & Rađo, 2004). When it comes to explosive power, a great many of its possible definitions can be found in the literature. Explosive power is the ability of short-term maximal mobilization of the muscle forces in order to speed up body movement (Herodek, 2006, 52). Explosive power can also be defined as the ability to manifest maximal strength over a maximally short period of time (Nićin, 1996, Stojiljković, 2003). Thus, explosive power represents an important factor in any activities which require great acceleration of the body mass, the mas of individual body parts, or an external object.

Research has indicated that a complex training program can be used to influence better nerve-muscle adaptation and maximal force, and the speed at which that force is manifested, where primarily, a combination of concentric, eccentric-concentric explosive exercises lead to the rapid generation of muscle force (Adams, O'Shea, Katie, & Climstein, 1992; Burger, Boyer-Kendrick, & Dolny, 2000; Fatouros, et al., 2000; Jensen, & Ebben, 2003; Kukrić, et al., 2009). In addition, it is also necessary to individualize the approach, and develop methods of optimization of load dosing from the aspect of generating optimal firmness of the joints in jumping exercises (Mrdaković, Ilić, Vulović, Matić, Janković, & Filipović, 2014). Thus, the strength and power, as closely bound abilities, are not independent (Harasin, 2003).

Explosive power, speed and agility are motor skills characteristic of elite basketball players (Cronin, McNair, & Marshall, 2003; Trninić, 2006; Trninic, & Dizdar, 2000) and are of vital importance for success in contemporary basketball. The vertical jump is connected to the speed realized over short distances (Wisloff, Castagna, Helgerud, Jones, & Hoff, 2004), while in some studies the vertical jump is the best indicator of the speed abilities of athletes (Morin & Belli, 2003). It is a known fact that jump height to a certain extent is influenced by maximal force, as well as intramuscular and intermuscular coordination (Dutchie, et al., 2002).

Motor and functional abilities have a great influence on results in combat sports, especially the power which has a positive effect on the achievement of elite sport results (Beachle, 1994; Hirtz & Starosta, 2002; Duraković, 2008; Cicović & Pelemiš, 2011). In judo, power is necessary when it comes to the timely activation of muscles which act as agonists and antagonists in short time intervals, prior to the realization of the eccentric-concentric contraction in the immediate interaction with the opponent (Bratić, 2003).

The manifested explosive power depends on the percentage and content of motor units of the appropriate muscle group (Branković & Bubanj, 1997). Typical examples of this ability are jumping and throwing athletic disciplines, that is, such movements when the athlete does not have time to develop maximal power, but instead in the shortest possible time acts on the equipment or the surface with the aim of achieving the best result. Explosive power, as such, represents one of the determinants of success in all activities which require external muscle force in very short periods of time (Newton & Kreamer, 1994).

In the military, for the successful performance of the assigned tasks, a high level of motor skills is needed. It is frequent that in the armed services tasks are performed in difficult meteorological conditions and under load conditions (protective masks, war equipment, protective clothing), when aerobic endurance is manifested. In addition to aerobic endurance, leg power is also of great importance for long distance marching, when going to or returning from an exercise area of firing range. The importance of explosive power can be noted in overcoming various obstacle courses used for training, parachute jumps, rapid boarding onto and jumping from helicopters, storming various objects, etc. There are numerous situations where the motor skills of a professional soldier, in addition to practice, also directly determine the success of task performance.

The subject matter of this research was muscle power and specific fitness abilities. The aim of the research was to determine the influence of explosive power on the results in navigating an infantry training obstacle course.

METHODS

Subjects

The research was carried out on a sample of the members of the Special Brigade of the Serbian Armed Forces, members of the 63rd Parachute Battalion. In total 98 participants took part in the study, with an average age of 30±0,5 yrs. The participants included in this sample belong to a physically active population. As part of their physical training, they exercise every day for a period of 90 minutes.

All of the participants were in good health during the study. Their average body height was 180.82 cm, and average body mass was 83.39 kg.

Procedure

Two groups of measuring instruments were used in the study: the first, predictor group, consisted of six parameters for the evaluation of muscle power, and the second, the criterion group, consisted of a test for the evaluation of fitness abilities, used to evaluate navigating an infantry training obstacle course. To evaluate muscle power, the Myotest device was used (Myotest SA, Sion, Switzerland).

The Myotest device relies on three-dimensional accelerometry technology and provides the technology and methodology for the evaluation of explosive power (Živković, M. D. 2014). The predictor group of measuring instruments for the evaluation of explosive power consisted of the following : BENCH PRESS power; BENCH PRESS power max; BENCH PRESS force; CMJ power; CMJ power max; CMJ force. The result is automatically presented on the screen following testing, and represents the average of three best repetitions.

Power (W) provides information on the ability to generate mechanical energy during time, force (N) provides information on the ability to produce the greatest dynamics in contrast to load, while speed (cm/s) represents the result of effort: stronger impulse, greater speed. To evaluate specific fitness abilities, the test of navigating an infantry training obstacle course was used, prescribed based on the standards for the evaluation of physical abilities of the members of the Special Brigade of the Serbian Armed Forced. The infantry training obstacle course is a unique and universal obstacle course for the complete development of physical abilities, 240 meters long, consisting of 18 different elements, equally distributed. The obstacle course consists of the following: a wire net, a wicker wall, a wooden picket fence, a log, two beams, a raft, a horizontal ladder, a wire fence, uneven bars, combined ladders, three beams, open-door-windows, a tunnel, logs, a corridor, a leaning wooden fence, floor beams, a trench (Guidelines for the Physical Training of the Serbian Armed Forces, 2011).

Statistical analysis

For all the variables (predictor and criterion) we calculated the basic descriptive statistics: means (Mean), standard deviation (Std.Dev), minimal (Min) and maximal (Max) results, range (Range). The influence of certain power parameters of the speed of navigating an infantry training obstacle course was determined using a regression analysis. The statistical package Statistica 7.0 was used to process the data.

RESULTS

By analyzing the fitness abilities of the participants, and the means of the tests such as the bench press (753,990 W) and CMJ (37,239 W), we can conclude that the explosive power of the participants is at a high level (Table 1).

Based on the means of the results for the discipline of navigating an infantry training obstacle course (139 s) in relation to the standard for evaluating members of the Special Brigade of the Serbian Armed Forces, we can conclude that we are dealing with physically well-prepared participants.

Table 1. Descriptive statistics parameters of power and the obstacle course

	Mean	Min	Max	Range	St.Dev
BENCH PRESS power	753,990	437,00	1220,00	783,00	163,838
BENCH PRESS power max	798,367	464,00	1270,00	806,00	171,947
BENCH PRESS force	537,643	342,00	672,00	330,00	57,317
CMJ power	37,239	25,60	49,70	24,10	4,745
CMJ power max	34,165	18,50	50,70	32,20	7,581
CMJ force	21,551	17,10	28,80	11,70	2,366
Obstacle course	139,082	99,00	183,00	84,00	15,466

Table 2. A cross-correlation of the parameters of power and the results for navigating an infantry training obstacle course

	BENCH PRESS power	BENCH PRESS power max	BENCH PRESS force	CMJ power	CMJ power max	CMJ force	Obstacle course
BENCH PRESS power	1						
BENCH PRESS power max	,99**	1					
BENCH PRESS force	,92**	,91**	1				
CMJ power	,34**	,35**	,28**	1			
CMJ power max	,08	,09	,02	,22*	1		
CMJ force	,16	,15	,13	,26**	,73**	1	
Obstacle course	-,26**	-,25*	-,25*	-,37**	-,16	-,14	1

Legend: ** - statistically significant at the .01 level; * - statistically significant at the .05 level

Table 3. The significance of the multiple correlation and the coefficient of determination

R	R^2	F(6,92)	p
.422	.178	3.28	**.006**

Legend: (R) – multiple canonical correlation coefficient of the criterion variable and predictor system, (R^2) - coefficient of determination, F - F test, (p) – level of significance.

Table 2 shows the cross-correlation between the analyzed parameters of power and the results for navigating an infantry training obstacle course. Based on the presented values, we can note that between the variables for the obstacle course and BENCH PRESS power there is a low negative correlation (-,37), including BENCH PRESS power (-,260), BENCH PRESS force (-,254) and BENCH PRESS power max (-,252). We can also note a low negative correlation with CMJ power max (-,169) and CMJ force (-,149).

Based on the values of the multiple correlation coefficient (R), .422, we can conclude that there is a moderate linear connection between the predictor variables and the criterion variable (Table 3). The influence of the set of predictor variables on the criterion is explained with approximately 18% (R2= .178). Even though this percentage of the explained variance is low, based on the significance of Fisher's test (F=3,28) we can conclude that the selected model is acceptable, that is, the changes in the variables from the regression model lead to significant changes in the values of the dependent variable (criterion). The selected parameters of power have a statistically significant influence on the speed of navigating an infantry training obstacle course (p= .006).

Table 4. The connection between power and the speed of navigating an infantry training obstacle course

	R	Part R	Beta	t	p
BENCH PRESS power	-,047	,069	-,498	-,679	,499
BENCH PRESS power max	,049	,063	,546	,782	,436
BENCH PRESS force	-,056	,069	-,209	-,820	,414
CMJ power	-1,036	,341	-,318	-3,036	,003
CMJ power max	-,329	,295	-,161	-1,114	,268
CMJ force	,537	,958	,082	,561	,576

Legend: R – simple correlation, Part-R – partial correlation, Beta – standard coefficient of the partial regression of each predictor variable and the criterion, t- t test, p – significance of the correlations between individual predictor variables and the criterion

By studying the t-values and the corresponding significance in Table 4, we can draw the conclusion that jump height – CMJSnaga (,003) has the only and statistically significant influence on the speed of navigating the obstacle course. The obtained results only confirm that in this case power and speed are vital for navigating many obstacles, as is the explosive power of the lower extremities

DISCUSSION

Based on the analysis of the results in Table 1, which shows the values of BPsnaga and BPSnagamax, we can note great oscillations between the minimal and maximal recorded values, which provides us with an image of physical ability of the best prepared and weakest participant. However, the mean values of BPSnaga (753,99) and BPSnaga max (798,37) indicate that this is a sample whose physical fitness is at an enviable level. The case is much the same with the values of the CMJSnaga where there is also a notable difference between minimal and maximal measured values. The mean values of CMJSnaga (37,24) indicate that the participants included in this sample have good height take off, that is, good explosive power of the lower extremities.

By comparing the obtained average result for the obstacle course (139.02) with the recommended standard (115-160), we can conclude that the fitness abilities of the participants are on a satisfactory level (Guidelines for the Physical Training of the Serbian Armed Forces, 2011).

Based on the results (Table 2), we can conclude that there are certain cross-correlations between the analyzed parameters of power and the results for navigating an infantry training obstacle course. It should be pointed out that the results for navigating an infantry training obstacle course in addition to power are also significantly influenced by technique, which might indicate that this factor to an extent influenced the results of certain participants. The greatest correlation was noted between the variables for the obstacle course and CMJSNAGA (,372), which indicates that the successful completion of the obstacle course is greatly influenced by the explosive power of the lower extremities. The results indicate that with an increase in the explosive power of the legs, there is a decrease in the time needed to navigate the obstacle course. Based on the existing research, certain correlations were confirmed which also indicate that the vertical jump is connected to the speed realized over short distances (Wisloff, Castagna, Helgerud, Jones, & Hoff, 2004), and that the vertical jump is the best indicator of the speed abilities of athletes (Morin & Belli, 2003).

The research results indicate that in the case of navigating an obstacle course, BP.SNAGA (-,260), BPSILA (-,254), and BPSNMAX (-,252) also have an influence. We can conclude that when navigating various obstacles, in addition of explosive power of the lower extremities, explosive power of the arms and pectoral muscles is also important, but to a lesser extent. The obtained results indicate that greater explosive power of the arms and pectoral muscles also decreases the time needed to navigate the obstacle course. This is also confirmed by the current research which indicates that motor skills have a very pronounced role in the manifestation and realization of athletic movement structures such as running, jumping and throwing disciplines, and that they realize certain relations which are manifested through sports results or an evaluation of the success of performing a given movement technique (Pavlović & Radinović, 2010). There are many studies in which power is defined as the precondition for the significant increase in the level of certain motor dimensions and motor tasks (Bratić & Nurkić, 2005; Bratić et al., 2008).

As assumed, motor skills have a significant effect on the successful completion of motor tasks, and by analyzing the influence of a set of predictor variables, in our case power, it was confirmed that power has a statistically significant influence on the success in navigating an infantry training obstacle course (Table 3). The presented results agree with the current research which indicates that the motor skills of an individual directly determine the success in performing physical activities (Nedeljković, 2007). The obtained results are in agreement with the previous studies in which the positive influence of power on achieving top sports results was determined (Beachle, 1994; Hirtz & Starosta, 2002; Duraković, 2008; Cicović & Pelemiš, 2011; Branković & Bubanj, 1997).

Based on the results shown in Table 4, we can conclude that height jump - CMJSnaga (,003) has the only and statistically significant influence on the speed of navigating an obstacle course. The explosive power of the lower extremities has once again proven to be an important factor in activities which require great acceleration in body mass and overcoming a certain space filled with various obstacles. Also, its significance can be justified by the number of jumps and landings between the obstacles on the course, where during landing and establishing contact with the ground, the strength of the lower extremities decreases the period of amortization. All this has been confirmed in numerous studies (Morin, & Belli, 2003; Wisloff , Castagna, Helgerud, Jones, & Hoff , 2004, Cronin, McNair, & Marshall, 2003; Trninić, 2006; Trninic, & Dizdar, 2000; Newton & Kreamer, 1994).

CONCLUSION

The aim of the research was to determine the influence of power on the speed of navigating an infantry training obstacle course. Two groups of measuring instruments were used: the first, predictor group, consisted of six parameters for the evaluation of power, and the second, criterion group, consisted of a test for the evaluation of fitness abilities, which were evaluated by navigating an infantry training obstacle course . To determine the connection between the set of predictor and criterion measuring instruments, a regression analysis was used. The results of the regression analysis have indicated that certain correlations exist between certain parameters of power and success in navigating an infantry training obstacle course. The most significant are the following:

Jump height - CMJ power (,003) had the only a statistically significant influence on the speed of navigating an obstacle course,

The greatest correlation was noted between the variable of the obstacle course and CMJ power (-,372), which indicates that the success in navigating an obstacle course was influenced the most by the explosive power of the lower extremities,

INFLUENCE on navigating the obstacle course was also determined for BENCH PRESS power (-,260), BENCH PRESS force (-,254), and BENCH PRESS power max (-,252), which indicates that in addition to explosive power of the lower extremities, the explosive power of the arms and pectoral muscles is also relevant, but to a lower extent.

It should be mentioned that in addition to explosive power, other factors could have an influence on the success of navigating an infantry training obstacle course, but they fall outside of the scope of this research.

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THE IMPACT OF THE SCHOOL OF SPORT ON MOTOR ABILITIES OF PRESCHOOL CHILDREN

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SUMMARY

The aim of this study was to determine the effects of a School of Sport training program on health-related fitness in preschool children. The study included a total of 58 children aged five to six and a half years, of whom 14 girls and 44 boys, involved in a 12 week of classes. The variables were selected within the battery of tests Eurofit, measuring abdominal strength, flexibility, aerobic fitness and upper and lower body strength, speed and agility. The results showed average initial level and later dynamic increase in the physical fitness of the participants. Pre-test to post-test values showed significant improvements in all tested variables ($p<0.05$). Therefore, participation in this kind of training programs must be recommended as a positive activity for preschool-aged children. Additionally, the results can provide useful information for optimizing the training loads of children involved in a School of Sport.

Keywords: Strength, Speed, Flexibility

INTRODUCTION

The influence of a continuous, well-planned and organized engagement with a certain physical activity is of great importance for the preservation and maintenance of a good health condition and the formation of a personality, especially in preschool children. Preschool education as a first step, the first level of the education system in Serbia includes the specific developmental period of the child in the age from one to six years. This is a sensitive period for the intense psychomotor, affective and cognitive development of the personality of the child. The findings of previous studies reinforce the need for the evaluation of motor performance in preschool-aged children, in order specific individual motor profiles to be established for optimizing and adapting early intervention programs (Giagazoglou et al., 2011)

Little evidence exists about the prevalence of adequate levels of physical activity and of appropriate screen-based entertainment in preschool children. The majority of young children are not participating in adequate amounts of physical activity and in excessive amounts of screen-based entertainment. It is likely that physical activity may decline and that screen-based entertainment may increase with age. Compliance with recommendations may be further reduced. Strategies to promote physical activity and reduce screen-based entertainment in young children are required (Hinkley, Salmon, Okely, Crawford, & Hesketh, 2012)

Activities of the School of Sport program are mostly based on the natural forms of movement that include: running, walking, jumping, skipping, creeping, throwing and catching props, climbing, pushing... With this kind of sports school development, all kinds of motor abilities, endurance, agility, flexibility, agility, coordination, balance will develop. The foundations of fundamental movement skills are laid in early childhood and essential to encourage a physically active lifestyle (Cools, Martelaer, Samaey, & Andries, 2009).

From the previous literature there is recommendations on the best approach in assessing motor function in pre-school children (Ortega et al., 2015; Piek, Hands, & Licari, 2012), also development of different motor skills (Cliff, Okely, Smith, & McKeen, 2009; Iivonen et al., 2013; Laukkanen, Pesola, Havu, Sääkslahti, & Finni, 2014; Williams et al., 2008). Still, there is a lack of investigations with intervention and training programs for developing motor abilities in preschool children. The aim of this research is to determine the impact of the School of Sport on motor abilities of five to six and a half years old children.

METHODS

Subjects

The study included a total of 58 children aged five to six and a half years, of whom 14 girls and 44 boys who at the beginning of the research were members of the School of Sport "Master Mini" from Belgrade. In addition to regular physical education activities in kindergartens, the group was subjected to physical exercise for 12 weeks, 60 minutes twice a week. Ethical approval was granted by the University Ethics Committee. Prior to data collection parental consent and child assent was obtained. No child had any reported history of learning difficulties or any behavioural, neurological or orthopaedic problems that would qualify as exclusionary criteria for this study.

Procedure

The day before the test, the motor test battery was introduced to all the children, who did three test trials. Children were measured indoor, after standard warm-up (5 minutes of running, and 10 minutes of dynamic stretching). They were encouraged to show maximum effort in all tests. These tests were chosen because they have been clearly defined and validated in other studies (Van Beurden et al., 2003), they are easy to administer and time efficient, and they cover a variety of skill components. The assessment of motor abilities was assessed by a fitness test battery, with the following variables:

1. Running 20 m from the high start - Sprint;
2. Polygon backward - Polygon;
3. Hand tapping
4. Sit and reach test
5. Standing broad jump
6. Sit-ups
7. Chin-ups

Measuring instruments

The measuring instruments for motor testing were used: stopwatch, school bench and chair for taping, mat, whistle, coloured adhesive tape, matte with scrollbars in centimetres, springboard and measuring tape, according to protocols described in many studies.

All conducted measurements were carried out by the authors personally with associates, graduated professors of physical education and sport.

Specific physical exercise program

The physical exercise program at the "Master Mini" School of Sport focuses on the development of basic motor skills, consisting of exercises for the development of motor skills, elements of gymnastics and athletics and techniques of team sports. The program was designed to cover as many different motor skills as possible. The practice of exercise lasted for 12 weeks, twice a week for 60 minutes. Six different types of the class have been realized.

The classes in the sports school "Master Mini" included:

- Artistic gymnastics and exercises on the apparatus (basics of acrobatics and exercises on the balance beam and bars),
- Balance exercises (control of body holding, acquiring feelings for movement).
- Basic locomotor skills (walking, running, jumping and skipping).
- Manipulative skills: manipulating objects (various props, balls).
- Elements of corrective gymnastics (exercises for correcting bad stance, flat feet, "x" or "o" legs, bowed shoulders, kyphosis, scoliosis, lordosis).
- Basics of sports with a ball (basketball, handball, volleyball, football).
- Coordinating polygons, motor polygons, polygon skills, polygons with obstacles, competitive polygons.
- Exercise skills and proper fall.
- Exercises with props.

Statistical analysis

All data analyses were performed in IBM SPSS Statistics 19.0 statistical program. The following basic central and dispersion parameters were calculated:

- The minimum value of the results (Min)
- The maximum value of the results (Max)
- The arithmetic mean (Mean),
- The standard deviation (SD),
- The coefficient of variation (CV).

The Kolmogorov-Smirnov test was used to assess the normal distribution of the variables. The curvature of distribution is determined by the coefficient of asymmetry ("Skewness"), and the distribution is distributed through the coefficient of flattening ("Kurtosis"). To determine the statistically significant difference in the mean values of the results at the initial and final measurement, the T-test for the dependent samples was applied.

RESULTS WITH DISCUSSION

This chapter presents the results of research and interpretation of the obtained data by following the order of the data processing methods. The basic descriptive statistical parameters of all variables included in the survey, as well as the distribution normality of the Kolmogorov-Smirnov test, are shown in Table 1 and 2. Table 1 shows the central and dispersive parameters of the distribution of motor abilities of pre-school children at initial, and Table 2 at final measurement. All examined variables have a normal distribution.

Table 1. Descriptive statistical parameters at initial measurement

	Min.	Max.	Mean	SD	Skew.	Kurt.	CV	K-S
Polygon	129.00	359.00	198.31	50.06	.93	.66	24.24	.95
Plate Taping	14.00	28.00	19.93	3.21	.15	-.43	16.11	.57
Sit and reach	25.00	55.00	40.17	7.46	-.02	-.59	18.57	.77
Standing broad jump	60.00	144.00	106.50	19.65	-.22	-.67	18.45	.62
Sit-ups	2.00	33.00	19.87	7.14	-.21	.07	35.93	.76
Bent arm hanging	10.00	434.00	137.59	97.34	1.01	.54	70.75	1.04
Sprint	42.00	70.00	50.35	5.14	1.30	2.99	10.21	1.0

N - number of respondents, Min - minimum score, Max - maximum score, Mean - mean value, SD - standard deviation, Skew. - coefficient of asymmetry, Kurt. - coefficient of curvature, K-S – Kolmogorov-Smirnoff test, CV - coefficient of variation, in%

Table 2. Descriptive statistical parameters on final measurement

	Min.	Max.	Mean	SD	Skew.	Kurt.	CV	K-S
Polygon	107.00	260.00	156.79	32.30	1.31	2.19	20.60	.75
Plate Taping	18.00	30.00	23.09	2.71	.51	.078	11.74	.78
Sit and reach	29.00	60.00	44.06	7.44	.29	-.37	16.89	.64
Standing broad jump	74.00	160.00	118.68	15.27	-.12	.76	12.87	.52
Sit-ups	4.00	41.00	22.76	7.00	.29	.82	30.76	.86
Bent arm hanging	33.00	479.00	173.56	114.99	1.28	.89	66.25	1.35
Sprint	40.00	60.00	47.94	3.95	.49	.39	8.24	.77

N - number of respondents, Min - minimum score, Max - maximum score, Mean - mean value, SD - standard deviation, Skew. - coefficient of asymmetry, Kurt. - coefficient of curvature

Table 3. Differences between initial and final measurement of motor abilities of children (T - test for dependent samples)

Var.	t	df	p
Polygon	8.701	53	.000
Plate Taping	-10.598	53	.000
Sit and reach	-7.056	53	.000
Standing broad jump	-7.769	53	.000
Sit-ups	-3.944	53	.000
Bent arm hanging	-3.259	53	.002
Sprint	6.368	53	.000

Table 3 shows the differences between the variables of motor abilities between initial and final measurement. A statistically significant difference on the level of $p<.05$ was determined for all variables. These results indicate that the implemented program is very efficient and leads to the advancement of all motor abilities of preschool children. Similar to previous research, the program has shown that it is extremely effective and has contributed to the advancement of all abilities, even after a twelve-week program (Deli, Bakle, & Zachopoulou, 2006)

Although there are papers that examined specific physical exercise programs on the development of motor abilities of pre-school children who do not have any health problems, a greater number of papers have examined the effects of different exercise programs in children who already have some health problems or are lagging behind in motor development due to various types of disorders (Borgi et al., 2016; Halperin et al., 2013; Ketelaar, Vermeer, Hart, van Petegem-van Beek, & Helders, 2001; Whittingham, Fahey, Rawicki, & Boyd, 2010). There is also transversal design studies which examined the correlation between the overall physical activity of children and the level of their motor skills (Barnett, van Beurden, Morgan, Brooks, & Beard, 2009; Gray et al., 2015; LeGear et al., 2012; Williams et al., 2008). These studies have shown that children with higher levels of physical activity have better motor skills. There is a need for more longitudinal studies on pre-school children (Rajović et al., 2016).

It is very important that all physical activities in preschool institutions are best exercised through the game because it is one of the basic and natural children of need. Children learn about the world through the game of skill, fantasize, create, acquire friendship and social relations (Stanojevic, 2016). It is therefore very important, from the earliest age, to provide the child with space and time for movement and playing, in order to achieve positive habits and lifelong love for sports. Our training program, therefore, included games designed to develop motor skills and abilities in accordance with the age of children. Research Stanojevic (2016) confirmed that there are statistically significant adaptive changes in motor skills under the influence of programmed exercise in pre-school subjects for six months, so our research was aimed at determining whether changes would occur if the program was shorter, for a total duration of 12 weeks. It has been proven that with the intensity, duration, and frequency of programmed exercise, we can provide an effective way of continuous improvement of motor abilities in pre-school children.

While the general, short-term goal of the physical exercise program is to encourage integrative child psychophysical development, it is important to emphasize that the long-term goal is to accept useful and healthy habits important for life. The purpose of this program is to develop habits for regular exercise in the future, a healthy lifestyle, and love for different sports. Therefore, it is most important to develop initially positive attitudes of children towards sports activities and everyday physical exercise. Improving motivation and improvement in the overall developmental status of a child can facilitate later selection of talented individuals for certain sports disciplines or can only be a good basis for a sportive active lifestyle in adulthood.

CONCLUSION

In this study, 58 children aged 5 to 6.5 years participated, of whom 14 girls and 44 boys who were at the beginning of the research were members of the sports school "Master Mini" from Belgrade. Apart from regular activities from physical education in kindergartens, the group was subjected to physical exercise for 12 weeks, 60 minutes twice a week. All tests used in the research can be applied without additional material resources, for the purpose of periodic monitoring of motor abilities and further advancement.

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CONNECTION OF RECREATIONAL PHYSICAL ACTIVITIES AND VITALITY OF THE ELDERLY

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SUMMARY

An overview of the literature was carried out with the aim of determining the connection between recreational physical activities and the vitality of the elderly. Collection of literature was made using the Internet browser in available journals. The data processing method is descriptive because different training programs were applied in the collected studies, and measurements were made using different measuring instruments, therefore there was no possibility of comparing results with other methods. The results and conclusions reached by the authors of the study showed the correlation of various programs of physical activity with the overall health of the people who were exercising them. It has been established that physical activity affects the improvement of the health status and reduces the risk of coronary disease, stroke hypertension, obesity, chronic and other diseases. Moderate physical activity also protects brain functions, contributing to better learning and longer memory, and reducing depression in the elderly.

Key words: exercise, physical activity, age, health.

INTRODUCTION

Aging is a process of loss of functions, fragility and decay, weaknesses and limitations of each type. But, fortunately, such a tragic fate does not have to be accepted as its own scenario if a person is ready to accept an active lifestyle. In this case, instead of a tragic "opera", life will be shaped and filled with pleasures to the very end. Physical activity in people at a later age contributes to their better general health condition, making them less dependent on other people, and more satisfied with their lives (Weinberg & Gould, 2003). Aging, of course, leads to death, but at a rate that does not only depend on inheritance but also on how someone will choose to grow old. Thanks to the accelerated progress of medicine, more comfortable and more quality life, people get sick later. This means that there is a prolonged period in which people feel healthy and strong and that their lives are physically and emotionally fulfilled almost to the very end. Regular physical activity of moderate intensity should be an integral part of every individual's life, and should be applied in the prevention and elimination of health problems, especially those resulting from reduced movement, inadequate nutrition and excessive nervous tension. Unfortunately, a small part of our population exercises physical activity, which, in addition to the healthy aspect, provides good fitness. And those who decide to start with some exercise program will soon give up. The assumption is that no one has explained the point and purpose of exercising to them, and that exercise is not limited to the feeling of fulfillment and pleasure, but to the number of heart rate per minute and other medical factors (Morgan, 2001). Whether exercise in most days during the week that maintains muscle strength should be encouraged in older people (DiPietro, & Pierce, 2001).

An overview of the literature was carried out with the aim of determining the connection between recreational physical activities and the vitality of the elderly.

METHODS

The problem of work is the collection and systematization of studies, as well as the analysis of the results and conclusions reached by the authors. Collection of the necessary literature was done using the Internet search engine (Google Scholar, KoBSON, PubMed) in available journals, using key words: exercise, physical activity, age, health. The review covered 40 studies, more than half of which involved the interaction of physical activities and the fitness of older people. Systematization was performed according to the criterion of connection of physical activities with the aging process, chronic heart and blood vessels diseases, as well as mental illnesses of the elderly. The data processing method is descriptive, as different training programs were applied in the assembled studies, and the measurements were performed using different measuring instruments, which was why there was no possibility of comparing the results with other methods.

THEORETICAL REVIEW OF THE PROBLEM

Linkage of physical activities with the aging process

Some studies (Seals, 2003) have shown that moderate physical activity, according to years, has beneficial effects on arterial permeability. Elderly people who exercise three to five times a week rarely suffer from Alzheimer's disease (Larson, Wang, Bowen, McCormick, & Teri, 2006). It is known that aerobic capacity decreases with age of 8-10% per decade of life, but in inactive people. With active persons, this decrease is half (4-5%), while those who regularly exercise reduce the decline to a quarter (2-3%). In spite of this, as aerobic capacity decreases with age in varying percentages, people can improve this ability even in their seventies (De Vries and Housh, 1994). From the fifth decade of life, power also drops significantly faster due to loss of muscle mass, which contributes to more frequent falls and injuries during movement. This atrophy or loss of muscle fibers is called sarcopenia, which is due to insufficient engagement and decreased hormone secretion, and is associated with other disorders such as arthritis, osteoporosis and insulin resistance (Deschenes, 2005). To mitigate the effects of falls in the older age, exercises with load are needed (Beck, & Snow, 2003), which serve to act on reduced bone density on the extremities. In addition, increased calcium intake and running have also had positive effects on increased bone mass (Nevill, Burrows, Holder, Bird, & Simpson, 2003). This means that people who use their muscles at an age retain a high level of their functions and have a lower risk of other related disorders.

Linkage of physical activities with chronic and other diseases

Decline in working capacity is not necessarily linked to age, because physiological age is always a better indicator than chronological age. Physiological age is influenced by factors such as family tree, cholesterol, blood pressure, healthy habits, vision, hearing and other variables. Long-lived people and their offspring have a significantly higher amount of high-density lipoprotein (HDL) compared to low-density lipoproteins (LDL), which reduces the ability to paste cholesterol particles onto the inner walls of the arteries. However, although this positive variation is determined by genes, research has shown that regular exercise can increase the level of HDL (also called good cholesterol) (Baryalai, Atymon, Scheste, Schaefer, Cupples, 2003). Exercising sports activities during youth does not provide protection throughout life. Regardless of whether they were active at a young age, adults who regularly participate in physical activity have low risk of heart and blood vessel disease. Most active athletes, after completing their careers, completely cease to exercise or reduce the intensity of exercise. As the volume of activity decreases, most often, the caloric intake is retained, body weight increases, resulting in a decline in physical fitness. The rate of decline in the maximum oxygen consumption (VO2max) in former trained athletes after the age of 50 is associated with a decrease in the intensity of exercise (Pimentel, Gentile, Tanaka, Seals, Gates, 2003). However, if the level of exercise is maintained, the rate of decline in aerobic capacity can be reduced in their sixties or seventies. It is known that regular physical activity reduces the blood pressure of people of the middle and late ages, especially those who already have elevated pressure (hypertension), and the activities recommended are primarily so-called aerobic activities. Hypertension contributes to the heart's work under load because blood is ejected from the left ventricle, which leads to heart enlargement over time. Arteries and arterioles in the organism become more stiff and less elastic, leading to atherosclerosis, heart failure, heart attack, stenosis and kidney failure (Wilmore & Costil, 2008). The results of numerous studies show that the risk of heart disease is indisputably linked to the extent of regular physical activity, and that moderate physical activity provides protection against certain chronic diseases. These activities have recently been increased by experts from the recommended minimum of 30 to 60 minutes. They doubled the recommendation to increase calorie consumption and thus slowed the obesity epidemic, which, as the results of numerous studies show, drastically increases the risk of cardiovascular disease (Brooks, Butte, Rand, Flatt & Cabellaro, 2004). In one study (Drygas, Kostka, Jegier, & Kunski, 2000), it was concluded that the physical activity during which 1,000 kcal per week was associated with a satisfactory low risk of coronary disease and that the consumption of 2,000 kcal per week was associated with an additional positive effects, especially on HDL values (so-called good cholesterol). The results of another study (Abramson & Vaccarino, 2002) also indicate that there is a link between regular physical activity and a reduced risk of coronary disease. American College of Sports Medicine and the American Heart Association (Nelson, Rejeski, Blair, Duncan, Judge, 2007) have made a recommendation on physical activity for the elderly, in which moderate aerobic activities are recommended. Lately, there is increasing evidence that physical activity is associated with a reduction in the risk of disease from certain malignant diseases, and the relationship between colon cancer and physical activity is most often studied. The conclusions of some studies suggest that regular physical activity shortens the time of passage of the contents through the intestine, which shortens the time of potentially carcinogenic substances. The lack of regular physical activity causes 12 to 14% of colon cancer (Slattery, 2004). The results of individual studies indicate that physical activity reduces the risk of developing prostate cancer, especially if it is more intentional (Friedenreich, 2004). It was found that this risk in hard exercise decreased by as much as 30%. In physically active individuals, the risk of developing pancreatic cancer is significantly reduced, especially among obese (Michaud, Giovannucci, Willett, Colditz, Stampfer, 2001).

Linkage of physical activities and mental health of the elderly

The logical question that we could ask, when considering the connection between physical activity and mental health, is whether mental health depends on physical activity or whether physical activity depends on mental health? The results of the studies show that the level of physical activity and good mental health are linked, and that the effects of moderate physical activity are better than high intensity activities. Improvement occurs regardless of age and general health. The effects of exercise on the bicyclic meter and treadmill in the aerobic zone contribute to the reduction of depression (Dimeo, Bauer, Varahram, Proest, & Halter, 2001), and physical activity of moderate intensity reduces the risk of depression in later life (Strawbridge, Deleger, Roberts, & Kaplan, 2002). A study conducted on women has shown that exercising physical activity, even once or twice a week, has a positive effect on mental health, feeling depressed or psychological disturbances (Kull, 2003). Women who are physically active have a lower mortality rate compared to sedentary women (Gregg, Cauley, Stone, Thompson, Bauer, (2003). The researchers, even in the Californian study (Breslow, & Enstrom, 1980), discovered a positive relationship between the physical and mental health.The results of the study (Laurin, Verreault, Lindsay, MacPherson, Rockwood, 2001) of five-year follow-up of older examinees have shown that higher physical activity is associated with a lower degree of risk of cognitive impairment of any kind Physical activities represent a strong protective factor in cognitive functions The results of the literature review (Angevaren, Aufdemkampe, Verhaar, Aleman, & Vanhees, 2008), which aimed at assessing the effectiveness of physical activity on cognitive function in older people, has shown that aerobic exercise increases cognitive and cardiorespiratory capacity. The effects are determined on motor and auditory functions attention. Moderate effects were noticed on the information processing speed and visual attention.

CONCLUSION

The results and conclusions reached by the authors of the study showed the correlation of various programs of physical activity with the general state of health of the people who were exercising them. Physical activity affects the improvement of the health condition and reduces the risk of coronary disease, hypertension, stroke, obesity, chronic and other diseases. It protects brain functions, contributing to better learning and longer memory. Helps people to look better, make them more vital and less tired.

Regarding the results obtained by the authors of the study of the effects of physical exercise on hypertension, in most cases the authors have come to the same conclusion that physical activity of moderate intensity favorably affects people with hypertension and leads to a significant reduction in blood pressure. Physical activity also maintains muscles that burn energy, helps maintain body weight in healthy frames and is a basic means in the stress control program. Significantly reduces the degree of depression in all age groups and maintains an optimal level of form.

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PHYSIOLOGY OF RECREATIONAL SMALL-SIDED GAMES: BRIEF REVIEW

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SUMMARY

The aim of this study was to provide a brief review of evidence pertaining to the physiological responses during recreational small-sided games (SSG) depending modifications in the game format. Research indicates absolute heart rate (HR) responses during football match-play vary from 157 ± 10 beats·min^{-1} to 174 ± 10 beats·min^{-1}, corresponding to relative responses of 79 ± 4% maximum heart rate (HR_{max}) to 91 ± 2% HR_{max}, which reflect considerable demands imposed on the cardiovascular system of players. Mean blood lactate values ranged from 4.5 to 7.4 mmol·L^{-1} during recreational SSG in football, indicating an important glycolytic energy contribution. The collective evidence suggests decreasing the number of players involved in SSG increases physiological demands imposed on players. Therefore, all game formats can be used as an effective strategy to improve cardiorespiratory fitness, but players (particularly obese and overweight) should be aware of their limit because the increased metabolic and physiological demands experienced during SSG (> 90% HR_{max}) with a fewer players (3 vs. 3) might lead to an increased risk of adverse cardiac event.

Keywords: team sports, heart rate, blood lactate concentration

INTRODUCTION

It is well established that a sedentary lifestyle is related with chronic diseases which have an enormous impact on healthcare costs worldwide. Traditionally, endurance-based activities such as walking, aerobic running, and cycling have been recommended for improving health profile. However, more recently, it has been reported that high intensity interval training (HIIT) and small-sided games (SSG) provide similar or better effects on cardiorespiratory fitness, muscle fitness and insulin sensitivity (Babraj et al., 2009; Helgerud, Engen, Wisløff, & Hoff, 2001; Milanović, Sporiš, & Weston, 2015; Nybo et al., 2010). Currently, SSG are one of the most common drills used by amateur and recreational players to improve physical fitness (Milanović, Pantelić, Čović, Sporiš, & Krustrup, 2015; Milanović et al., 2018).

Recreational SSG is perceived less strenuous than HIIT, in terms of lower heart rate (HR) response in zone between 90-100% maximum heart rate (HRmax) (Cvetković et al., 2018) and perceived exertion (Krustrup et al., 2010), while concurrently increase player motivation and compliance. The American College of Sports Medicine (ACSM) recommended that the intensity of the physical activity should be between 60-85% HRmax to improve cardiovascular fitness (ACSM, 2013). However, HR values obtained in previous studies demonstrated that the intensity of the SSG in football exceeds recommended threshold in certain periods (Randers et al., 2010; Randers, Ørntoft, Hagman, Nielsen, & Krustrup, 2018a). Due to the intermittent nature of SSG it is not possible to constrain the intensity within recommended guidelines. However, modifications in the game format (number of players, court size, and presence of goalkeepers) have been shown to affect physiological demands during SSG (Rampinini et al., 2007; Randers et al., 2010).

Halouani, Chtourou, Gabbett, Chaouachi, and Chamari (2014) have summarized the literature relating to the variables affecting SSG intensity in semi-professional and professional football players. However, in the majority of the included studies plenty of balls are kept around the court, including coach´s encouragement to maximize exercise intensity which is typical in the organized training process. In contrast, in recreational SSG only one ball is available and there is no coach encouragement to optimize exercise intensity. Furthermore, a previous review by Halouani et al. (2014) was based research conducting in semi-professional and professional football players and it has been shown that physiological responses differ between amateur and professional players (Dellal, Hill-Haas, Lago-Penas, & Chamari, 2011).

Therefore, the aim of this study was to provide a brief review of evidence pertaining to the physiological responses during recreational SSG depending modifications in the game format.

Heart rate responses

HR is the most common measure used to objectively monitor exercise intensity, which provides information regarding physiological stress encountered during match-play (Stojanović et al., 2018). Research indicates absolute HR responses during football match-play vary from 157 ± 10 beats·min^{-1} to 174 ± 10 beats·min^{-1}, corresponding to relative responses of 79 ± 4% HR_{max} to 91 ± 2% HR_{max} (Table 1), which reflect considerable demands imposed on the cardiovascular system of players. The wide variation in responses are likely attributable to the different player numbers and pitch size. Table 1 summarizes studies that have examined the influence of pitch size and the number of players on SSG intensity.

Rampinini et al. (2007) examined the effect of four different game formats (3 vs. 3, 4 vs. 4, 5 vs. 5, and 6 vs. 6) on HR response with an increase of the pitch size. Higher HR responses were observed in the game format with the small number of players (89.5 vs. 88.7 vs. 87.7 vs. 86.4 % HR_{max}). Likewise, Randers, Andersen, Rasmussen, Larsen, and Krustrup (2014) identified significant differences in player responses between 5 vs. 5 and 8v8 (court size 30 x 40 m and 52.5 x 68 m) with HR values increasing as the number of players on-court decreased (168 vs. 174 beats·min^{-1}). Further, Aslan (2013) found that an increase in player numbers (5 vs. 5 and 7 vs. 7) with a fixed court size resulted in a decrease in the % HR_{max} (79.4 vs.76.8). Also with the fixed size court, significantly higher mean HR responses were observed during 3 vs. 3 and 5 vs. 5 than during 7 vs. 7 (85.7 vs. 84.2 vs. 80.7 % HR_{max}) (Randers et al., 2018a). Although mean HR data were not different between 3v3 and 5v5, more time was spent with HR above 90% HR_{max} in 3 vs. 3 than in 5 vs. 5 and 7 vs. 7 (43 vs. 28 vs. 18%) (Randers et al., 2018a). In contrast to the above mentioned data, non-significant effect of the number of players on HR was reported during 3 vs. 3, 5 vs. 5, 7 vs. 7 along concurrently changed pitch size (Randers, Nielsen, Bangsbo, & Krustrup, 2014b). It is important to note, that in order to isolate the effect of the number of players, court size should be kept unchanged. Finally, although some studies (Randers et al., 2014b; Randers et al., 2010) have found no effect or lower HR response in game formats with more players the collective evidence suggest decreasing the number of players involved in SSG increases the cardiovascular stress imposed on players. Therefore, all game formats can be used as an effective strategy to improve cardiorespiratory fitness, but players (particularly obese and overweight) should be aware of their limit because the increased metabolic and physiological demands experienced during SSG with a fewer players (3v3) might lead to an increased risk of a cardiac event.

Numerous studies have been conducted to investigate the influence of pitch size on HR response in elite, semi-elite adult and youth football players (Casamichana & Castellano, 2010; Hill-Haas, Dawson, Impellizzeri, & Coutts, 2011; Kelly & Drust, 2009), but little is known about how different pitch size affect cardiovascular responses in recreational players. To date, only two studies have determined HR response altering pitch size in recreational and amateur players, reporting conflicting results (Aslan, 2013; Rampinini et al., 2007). The equivocal findings regarding the influence of pitch size on exercise intensity and the limited investigation specifically in recreational SSG emphasize a need for research in this area.

Blood lactate concentration

In addition to HR response, blood lactate concentration also provides important insight into physiological demands during SSG. Blood lactate concentration has been extensively used as an indicator of energy production from rapid glycolysis. Mean blood lactate values ranged from 4.5 to 7.4 mmol·L^{-1} during recreational SSG in football (Table 1), indicating an important glycolytic energy contribution.

Table 5 Acute physiological load during recreational small-sided games in football players

Study	Participants characteristics	Small-sided games details	Heart rate response				Lactate (mmol·L^{-1})	Perceived exertion	Outcomes between comparison groups
			Mean absolute (b· min^{-1})	Mean relative (%HR_{max})	Peak absolute (b· min^{-1})	Peak relative (%HR_{max})			
Rampinini et al. (2007)	Amateur players, 24.5 ± 4.1 yr, (n = 20)	• 3 vs. 3; 3 x 4 min; 12 x 20 m • 3 vs. 3; 3 x 4 min; 15 x 25 m • 3 vs. 3; 3 x 4 min; 18 x		89.5 ± 2.9 90.5 ± 2.3 90.9 ± 2.0 88.7 ± 2.0 89.4 ± 1.8			6.0 ± 1.8 6.3 ± 1.5 6.5 ± 1.5 5.3 ± 1.9 5.5 ± 1.8	8.1 ± 0.6 8.4 ± 0.4 8.5 ± 0.4 7.6 ± 0.5 7.9 ± 0.5	HR, La, PE: 3 vs. 3 > 4 vs. 4 = 5 vs. 5 > 6 vs. 6

Study	Participants characteristics	Small-sided games details	Heart rate response				Lactate (mmol·L^{-1})	Perceived exertion	Outcomes between comparison groups
			Mean absolute (b· min^{-1})	Mean relative (%HR$_{max}$)	Peak absolute (b· min^{-1})	Peak relative (%HR$_{max}$)			
		30 m • 4 vs. 4; 3 x 4 min; 16 x 24 m • 4 vs. 4; 3 x 4 min; 20 x 30 m • 4 vs. 4; 3 x 4 min; 24 x 36 m • 5 vs. 5; 3 x 4 min; 20 x 28 m • 5 vs. 5; 3 x 4 min; 25 x 35 m • 5 vs. 5; 3 x 4 min; 30 x 42 m • 6 vs. 6; 3 x 4 min; 24 x 32 m • 6 vs. 6; 3 x 4 min; 30 x 40 m • 6 vs. 6; 3 x 4 min; 36 x 48 m • 3 min active recovery, without goalkeepers, with coach encouragement		89.7 ± 1.8 87.8 ± 3.6 88.8 ± 3.1 88.8 ± 2.3 86.4 ± 2.0 87.0 ± 2.4 86.9 ± 2.4			6.0 ± 1.6 5.2 ± 1.4 5.0 ± 1.7 5.8 ± 1.6 4.5 ± 1.5 5.0 ± 1.6 4.8 ± 1.5	8.0 ± 0.5 7.2 ± 0.9 7.6 ± 0.6 7.5 ± 0.6 6.8 ± 0.6 7.3 ± 0.7 7.2 ± 0.8	Mean relative HR, La: large court > small and medium court PE: small court < medium court = large court
Katis and Kellis (2009)	Amateur players, 13 ± 0.9 yr., (n = 34)	• 3 vs. 3; 10 x 4 min; 15 x 25 m • 6 vs. 6; 10 x 4 min; 30 x 40 m • 3 min active recovery, 15 min between 5 and 6 part, + goalkeepers		87.6 ± 4.8 82.8 ± 3.2					Mean relative HR: 3 vs. 3 > 6 vs. 6
Randers et al. (2010)	Untrained male players 31 ± 2 yr., (n = 26); Untrained female players 37 ± 2 yr., (n = 21);	• 1 vs. 1; 5 x 6 min; M • 3 vs. 3; 4 x 12 min; M • 7 vs. 7; 4 x 12 min; M • 2 vs. 2; 5 x 10 min; F • 4 vs. 4; 4 x 12 min; F • 7 vs. 7; 4 x 12 min; F • 2 min recovery, 40 x 60 m	163 ± 3 163 ± 3 162 ± 3 156 ± 3 158 ± 4 155 ± 3	84.1 ± 0.7 84.0 ± 0.7 83.8 ± 0.7 82.1 ± 0.4 82.8 ± 0.4 81.3 ± 0.3	185 ± 2 187 ± 2 184 ± 2 176 ± 4 178 ± 4 177 ± 4	95.7 ± 0.9 96.8 ± 0.8 95.4 ± 0.9 92.5 ± 0.6 93.9 ± 0.5 93.1 ± 0.2			Peak absolute HR in males: 3 vs. 3 > 7 vs. 7; Mean absolute and relative HR in females: 4 vs. 4 > 7 vs. 7
Aslan (2013)	Recreational players, 31.7 ± 7.6 yr., (n = 10)	• 5 vs. 5; 40 min; 44 x 23 m • 7 vs. 7; 40 min; 44 x 23 m • 5 vs. 5; 40 min; 57 x 30 m • 7 vs. 7; 40 min; 57 x 30 m	164 ± 12 161 ± 13 167 ± 13 164 ± 13	79.4 ± 3.7 76.8 ± 4.4 81.7 ± 4.7 78.7 ± 4.3	185 ± 12 183 ± 13 188 ± 13 183 ± 16	97.7 ± 1.6 96.7 ± 2.0 99.2 ± 1.9 96.3 ± 3.4		12.4 ± 1.2 12.3 ± 0.9 13.2 ± 1.9 12.8 ± 1.2	Mean absolute, relative, Peak absolute, relative HR: 5 vs. 5 > 7 vs. 7
Randers et al. (2014b)	Recreational players, 33.0 ± 6.4 yr., (n = 12)	• 3 vs. 3; 15.5 x 31 m • 5 vs. 5; 20 x 40 m • 7 vs. 7; 23.5 x 47 m • 4 x 12 min, 4 min rest, 80 m^2 per player	159 ± 8 159 ± 11 157 ± 10	84.1 ± 3.9 84.5 ± 5.0 82.8 ± 5.1	182 ± 9 182 ± 9 181 ± 9	96.4 ± 3.4 96.3 ± 2.9 95.7 ± 4.4	5.9 ± 2.9 5.9 ± 2.4 5.5 ± 2.9	4,7 ± 1.6 4.9 ± 2.1 4.6 ± 1.8	
Randers et al. (2014a)	Elite and recreational youth players, 8-13 yr., (n = 86)	• 8 vs. 8; 52.5 x 68 m; 8-9 год. • 5 vs. 5; 30 x 40 m; 8-9 год. • 11 vs. 11; 105 x 68 m; 11-12 год. • 8 vs. 8; 52.5 x 68 m; 11-12 год. • 20 min; goalkeepers data were not included in analysis	168 ± 12 174 ± 10 171 ± 10 170 ± 10		198 ± 11 202 ± 8 199 ± 8 198 ± 9				Mean absolute, Peak absolute HR in 8 -9 yr.: 5 vs. 5 > 8 vs. 8
Randers et al. (2018a)	Recreational players, 32.6 ± 6.7 yr (n = 11)	• 3 vs. 3 • 5 vs. 5 • 7 vs. 7 • 4 x 12 min; without goalkeepers; 20 x 40 m; 4 min rest		85.7 ± 5.7 84.2 ± 5.1 80.7 ± 4.6			7.4 ± 2.7 6.1 ± 2.1 4.5 ± 2.2	6.7 ± 2.3 5.2 ± 2.2 4.3 ± 2.3	Mean relative HR: 3 vs. 3 and 5 vs. 5 > 7v7 La: 3 vs. 3 > 7 vs. 7 PE: 3 vs. 3 >

Study	Participants characteristics	Small-sided games details	Heart rate response				Lactate (mmol·L^{-1})	Perceived exertion	Outcomes between comparison groups
			Mean absolute (b· min^{-1})	Mean relative (%HR_{max})	Peak absolute (b· min^{-1})	Peak relative (%HR_{max})			
									5 vs. 5 and 7 vs. 7

Note: HR – heart rate; La – blood lactate concentration; PE – perceived exertion; M – male; F– female.

Rampinini et al. (2007) investigated the effect of altering player number on blood lactate concentration responses across four different conditions (3 vs. 3, 4 vs. 4, 5 vs. 5, and 6 vs. 6), reporting that SSG containing smaller number of players elicit greater blood lactate concentration. In line with previous observations, recent study (Randers et al., 2018a) found an increase of blood lactate concentration when the player number was decreased.

Rampinini et al. (2007) examined blood lactate concentration response across three different pitch sizes (12 x 20 m vs. 15 x 25 m vs.18 x 30 m), and found higher concentration on the large pitch size compared to the medium and small pitch size (6.0 vs. 6.3 vs. 6.5 mmol·L^{-1}).

Perceived exertion

In contrast to blood lactate concentration, rating of perceived exertion is a simple, non-invasive method of monitoring exercise intensity (Hill-Haas et al., 2011). In accordance with internal measures of physiological load (blood lactate concentration and HR response), varying number of players and pitch size also induced different perceived exertion (Rampinini et al., 2007; Randers et al., 2018a).

Conclusion and recommendations

The collective evidence suggests decreasing the number of players involved in SSG increases the cardiovascular stress imposed on players. Therefore, all game formats can be used as an effective strategy to improve cardiorespiratory fitness, but players (particularly obese and overweight) should be aware of their limit because the increased metabolic and physiological demands experienced during SSG (> 90% HR_{max}) with a fewer players (3 vs. 3) might lead to an increased risk of adverse cardiac event.

This brief review has demonstrated that, with the exception of football, other team sports have not been investigated thoroughly. Although, recreational basketball and handball may lead to broad-spectrum health benefits (Póvoas et al., 2017; Randers et al., 2018b) little evidence is available considering acute physiological demands during SSG. Therefore, future research should examine the influences of manipulating variables such as pitch area and player number in recreational basketball and handball. Furthermore, the equivocal findings regarding the influence of pitch size on exercise intensity and the limited investigation emphasize a need for research in this area.

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HOW TO MOTIVATE ELDERS TO ENGAGE IN PHYSICAL ACTIVITY

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SUMMARY

The interest towards exploring a more active lifestyle, ie. being physically active at an older age, as one of the key components of a healthier way of life with elders is viewed through interdisciplinary scientific research. Unless elders lead an active lifestyle, they expose themselves to the risk of reduced muscle mass, functional mobility, and with that the social surroundings will view people of the older age group as helpless and "socially less valuable", which will in turn create a psychological barrier in terms of further development and adaptation. Physical activity with elders over 65 years of age has shown to be a key factor in maintaining a desirable health condition with individuals from the aspect of primary medical care and the primary care of mental health at an older age. Research used to discuss this topic, which have studied the effect of motivation on physical activity, as well as changes that occur within the cognitive functions due to exercise at an older age, were analyzed and presented in this paper.

Keywords: older age, physical activity, motivation

INTRODUCTION

Motivation to participate in sports activities is a well researched topic with the aim of finding a model which will inspire a wider population to go from a passive to a more physically active way of life. In the last twenty years, aside from the general interest in this phenomenon, the interest to research a more active lifestyle has risen, ie. being physically active at an older age. Researchers were also interested not only about the functional changes which occur in the body, but also about the psychological changes which influence mental and physical health at an older age. Physical exercise is one of the pivotal components of a healthy lifestyle. It is hard to find a method which would be more useful to elders in all segments of mental and physical health, from an adequate physical activity and recreational standpoint. When an appropriate intensity, duration, frequency, type and purpose of a physical activity is determined, it can be applied from the earliest to the latest stage of life (Radenković, 2016).

Regular exercise is one of the most natural methods of preserving bodily vitality, preventing and reducing development of chronic and degenerative changes and diseases which appear with aging of the body (Andrijašević, M., & Andrijašević, M., 2006), however it is often the case with elders that this segment lacks motivation and interest the most (Bogdan & Babačić, 2016). It is obvious that psychological factors which determine positive healthy behavior, as well as awareness of one's own health and its changes, in today's sedentary and fast paced way of life are often not developed enough to produce positive health habits, such as dedications to physical activity (Prelog, 2017). One of the reasons for this is the human tendency to conformity, as well as avoiding physical strain and discomfort which muscle activity will produce (Andrijašević, 2010).

One's social surrounding often perceives the elderly as powerless and "socially less usefull", which in turn makes the elderly form a psychological barrier towards developing and adaptation of certain abilities and qualities in life (Skinner, 1983). From the aspect of primary medical care and primary care of mental health, especially at an older age, physical activity should be the main way of maintaining the desired health condition of an individual, ie. society in general.

This is at the same time the most economically acceptable way of preserving health, so with necessary intrinsic motivation it will not require a significant dedication of resources (Prelog, 2017). The secret to aging well is certainly in the positive approach to life (Habic, Đukić, & Marijanović. 2010). Regular physical activity can help the elderly reduce the risk of chronic diseases, help maintain the illnesses they already have, help them function better both physically and mentally, to avoid injury like falling and to live longer independently (Bennet & Winters-stone, 2011). Numerous research have shown that the number of falls increases by 35-40% after the age of 60 and is the result of reduced muscle strength, balance, and flexibility (Hornbrook, Stevens, Wingfield, 1994; Hayes, Myers, Robinovitch, 1996). For example, intensity training with its many effects on strength, is safe and well accepted with healthy persons in their 80s, and causes adaptive neuromuscular change in physiological variables which are often connected to risk of falling and limits of one's ageing (Caserotti, et al., 2008). Many physiological, as well as psychological falls find their source in the lack of activity, and as such can be avoided (Schwenk, 1999). Muscle mass and strength are reduced by 30-50% between the ages of 30 and 80 (Daley, 2000). The main cause decline in muscle mass, muscle strength, motor functions and physical capabilities is the reduced number of muscle fibers (Caserotti, Aagaard, Larsen and Puggaard, 2008), as well as the limit to daily body activity (Milanovic, Pantelić, Sporiš, Krakan, & Mudronja, 2012). Research results show that muscle strength reaches its maximum in one's 20s and 30s, and stays stable in one's 40s, and that approximately 6% of muscle mass, and 12 to 14% of muscle strength is lost every ten years after reach 50 years of age, keeping in mind that it can be increased by 12% after several months of strength training (Lynch Metter & Lindle, 1999). Therefore, the main question is how to efficiently motivate people in their mature age to change their behavior and stay active as they age?

METHODS

In order to better acquire quality material to support this topic, browsing was conducted through numerous electronic data bases: KOBSON, EBSCO, PubMed, ScienceDirect, SCIndex and Google Scholar. This research includes papers that relate to the elder population over 65 years of age. Searching was conducted with a combination of terms connected to physical exercise, motivation, intrinsic and extrinsic motivation, how to motivate the elderly to engage in physical exercise, cognitive functions with the elderly who engage in physical activity etc. Relevant studies were acquired after detailed observation and after fulfilling the inclusion criteria. The descriptive method was used for the analysis of the acquired data.

RESULTS AND DISCUSSION

According to the definition of the World Health Organization, older people are between 60 and 75 years of age, old people between 76 to 90 years of age, and very old people are those above the age of 90. (Papalia, Olds & Feldman, 1992). Psychological theories of ageing mostly support this definition. Jung was the among the first who, in the 30s of the 20th century, defined the periods of physical development, and he differentiated the period of youth which starts after puberty and lasts until one's middle age (35-40). After forty years of life, which he calls the "the noon of life", comes the process of individuation, and it refers to a mature age of life. During that period a person will start to focus on themselves, become more aware of one's self and start searching for a goal, a meaning, and wholeness of one's own life (Birren & Schaie, 2001). The cognitive theory of adapting to ageing developed by Brandstadter (Brajković, 2010; Lacković-Grgin, 2014) assumes the existence of three core forms of facing the perceived or expected developmental losses during this adaptation: assimilation, accommodation, and immunization. Successful ageing, according to this theory assumes the balance between these tree forms of confrontation, and in the context of this papers topic, assimilation sets itself aside as the confirmation of the previously mentioned need for physical activity at an older age. Assimilation represents the confirmation of man's tendency to actively adjust or change according to his life situation, so that it better suits his personal goals and possibilities. For example, and older person will still engage in physical exercise, but instead of intensity training he or she will take walks outdoors.

Cognitive abilities will inevitably go through changes during one's life, and regular physical activity reduces the risk of dementia and weakening (cognitive decline) of cognitive abilities (Yaffe, Barnes, Nevitt, Lui, & Covinsky, 2001), as well as cognitive degeneration (cognitive impairment) at an older age (Laurin, Verreault, Lindsay, MacPherson, Rockwood, 2001). Certain studies claim that reduced physical activity and mobility in general increase the risk of failing cognitive functions (Keysor, 2003). Experimental research (Colcombe, Kramer, 2003) with the elderly show that even one aerobic training session can temporarily improve memory, attention, and reaction time. It is still impossible to describe in detail which exercise program would have the most benefit to physical and cognitive functions at an older age (Yaffe, et al., 2001), also, motivation to engage in sports activities is a well researched topic with the aim of finding a model which will inspire a wide population of people to change from a passive to a physically active life style (Bogdan & Babačić, 2016).

Motivation can be portrayed as a collection of impulses or needs of an individual which require action or initiation in order to achieve a goal. It doesn't matter what acquired knowledge and competence one may possess, if there is no motivation, it is hard to assume that the desired results will be achieved (Horga, 1993). Motivation is the inner moving force which supplies us with the power needed to achieve goals and satisfy needs. Extrinsic motivation (Sansone & Harackievicz, 2000) is characterized and moved by the desire to achieve outer rewards, recognition. With this kind of motivation, rewards like trophies and material gain push the individual to try harder and dedicate oneself while achieving one's desired goals, but it is not without its limits. Opposite to this, intrinsic motivation could be defined as a collection of inner factors which affect the individual in a way where the desire to achieve a goal comes from within themselves (Petz, & Ivanović, 1987), without necessarily aiming towards achieving an outward kind of reward. In the beginning, motivation starts of as extrinsic, and later it gradually grows into its intrinsic variant.

Intrinsic motivation is of extreme importance when it comes to achieving supreme goals, expecially in creative, non routine jobs. It is of key importance with athletes and recreational athletes, especially in individual sports. Bogdan et. al (2016) state that extrinsic factors such as pay, bonuses, medals, recognition and other outside rewards result in positive outcome when it comes to routine work. Inner motivation and self-imposed extrinsic motivation inspire activity with elders, and after a motivated workout, positive factors that surface with research candidates are health and fitness, social/emotional advantages, weight management, stress management, enjoyment and physical appearance (Dacey, Baltzell & Zaichowsky 2008).

In order to analyze the influence of motivation for sports and exercise, a survey research was conducted on a sample of 200 people. The goal of the research was to examine the intrinsic and extrinsic factors that influence motivation for participation in sports activities in relation to age. People if the 20-40 age group view sports activities as a lifestyle. With persons of 40 to 60 and 60 and above, sports and exercise is generally practiced for health reasons. With people of 60 years of age and older, survey candidates who engage in no physical activity claim the main reason is lack of interest for sports and physical exercise. Of the most common reasons to avoid sports and exercise for the 20 to 40 and 40 to 60 years of age sample, the most important ones were lack of time and motivation, which confirms some results of previous research on the same topic (Bogdan & Babačić, 2016). Similar results, in connection to the age group of 60 to 80 years of age, were noted by Milanovic et. al (2012), where the authors have concluded that with ageing the interest for sports and participation in physical activities significantly drops.

However, even though the interest in participating in physical activities drops with one's age, the recommended amount of exercise for the elderly is the same as with adults aged 18-64, at least 150 minutes a week (around 30 minutes 5 days a week) of physical activity of medium intensity (Bennett & Winters-Stone, 2011).

Unless people at an older age lead an active lifestyle in terms of physical activity, they expose themselves to risk of reduced muscle mass, but also reduced functional mobility (Milanović, et al., 2012). The effects of circular training on the body of the elderly who exercise, in comparison to the elderly that don't, are visible through: a) higher maximum aerobic capacity; b) better economy of breathing, higher maximum volume of breathing; c) lower heart frequency in a state of stagnancy and intensity; the possibility of achieving higher heart frequency during activity; d) lower tendency for irregular heart rhythm; e) lower blood pressure in a state of stagnancy and intensity; f) better heart economy and function; g) bigger absolute muscle force; h) lower levels of lactic acid during body strain, (Medved, et al. 1987., prema Andrijašević, M., & Andrijašević, M., 2006). Certainly all the above mentioned positive results can be expected if all the criteria of physical activity are met, which foremost refer to an adequate intensity level, regularity in exercise according to one's age.

Bennet & Winters-Stone (2011) came up with some interesting results after a comparative study about whether motivation with elders is influenced more by an eight-week group cognitive behavioral therapy, or an individual approach. Long-term effects on motivation to exercise are achieved by one individual motivational session and 15 booster telephone calls, delivered by phone or computer, and this includes a big percentage of participants who fulfill the desired levels of physical activity, compared to a group which was motivated by group KBT or a control group.

Moreno-Murcia, Belando, Huescar, & Torres (2017) have researched the predictive relationship between perceived social support (by an instructor/trainer, and family), psychological needs, intrinsic motivation, health goals, regular physical activity and the satisfaction in life with a group of physically active women aged 18 to 82. These women have done aerobic, pilates, turns, strength training, and swimming three times a week, with a minimum of six months. The results have shown that there is a positive relationship between the perceived support autonomy (social support) and psychological needs, which are positively linked with intrinsic motivation. Intrinsic motivation is also linked with health goals (resistance to illness), which is positively lined to regular physical activity, and finally, physical education, ie. education about the importance of physical activity, have shown a positive relationship with the satisfaction in life. The results of this study have shown the need for social-cognitive physical interventions in order to maximize the advantages of physical exercise with women.

CONCLUSION

The question how to efficiently motivate the elderly to change their behavior and stay active as they age provided no concrete answer, but some recommendations are in order based on the research we have analyzed. The secret to good ageing is in a positive approach to life. Many physiological and psychological falls are due to physical inactivity and as such can be prevented. Motivation with people at an older age for physical activity, and especially intrinsic motivation, is positively linked with health goals, ie. resistance to illness, and education about the importance of physical activity at this age has a positive relationship with satisfaction in life. Physical activity has a positive influence on the prevention of developing disease and illness, and positive health attitude, but also on the psychological health and the integration of the elderly into society. Inactivity has a much higher effect on ageing than any other physiological factor. Research shown and theories which were covered by this paper state that any well dosed regular physical activity with adequate intensity and length will have positive results on psycho-physical health of adults aged 65 and up, rather than inactivity. We must certainly determine the motivational mechanisms which will inspire this age group that engages in no physical activity to start engaging in some. The stated conclusions could indeed serve as a guideline to future planning and programming of physical exercise and activity for the elderly and how to better motivate them to pursue them.

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PHYSICAL ACTIVITY LEVELS OF THE STUDENTS OF THE UNIVERSITY OF NIŠ

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SUMMARY

The aim of the research is to determine if there is a difference in the level of physical activity of students of four faculties of the University of Niš. The research includes students from the Faculty of Philosophy, Law, Economics and the Faculty of Electronic Engineering. The subject matter of research is a student population whose curricula do not include physical education classes. The results obtained in the analysis of differences in physical activity among students of the Faculty of Economics and Faculty of Philosophy indicate that there is a significant difference in the level of the students' physical activity. Based on the completed testing, we can conclude that there are no significant differences in the level of physical activity among the students of the Faculty of Law and Faculty of Philosophy, while in the case of the students of the Faculty of Electronic Engineering and Faculty of Philosophy we can conclude that the former are a little less active than the latter. Based on our analysis, it can be concluded that students of the Faculty of Law showed a significantly higher level of activity at work, while the least active students of the Faculty of Electronic Engineering were active during their commute. When it comes to household activities, students of the Faculty of Economics showed an enviable level of activity, while students of the Faculty of Philosophy were more active during their free time. On the basis of the obtained results it can be established that there is a significant difference in the level of physical activity among the students of the University of Niš.

Keywords: research, students, level of student's physical activity, results, testing

INTRODUCTION

Taking part in physical activities can cause certain changes in the psycho-physical health of an individual. Contrary to that, not taking part has either a minimal positive effect on the physical and psychological health of people, or none at all. As a result, the World Health Organization (http://www.who.int/) and International Federation of Sports Medicine (http://www.fims.org/) expressed concern that approximately one half of humanity is not sufficiently physically active. It is the recommendation of these organizations to put emphasis on regular physical activity which should become the basis for a healthy lifestyle. Children and adolescents should be given the opportunity to participate in programmed activities, so that regular physical activity will become a life-long habit. Regular physical activity of an individual should gradually increase with the aim of achieving at least 30 min of physical activity of moderate intensity. Scientific findings and facts on the positive health effects of physical exercise in all age categories should be popularized as much as possible. Furthermore, physical activity is closely related to mental health and well-being (Andrijašević et al, 2005). Physical culture is a very broad concept which includes all forms of physical activities in the field of physical education in educational institutions ranging from preschools to universities, elite sport activities, recreational sport, and kinesitherapy. Physical culture also includes complexes of sports facilities, and the equipment and props necessary for the realization of physical activities. Physical education as a constituent part of physical culture has a biological-health related, educational and bio-motor influence on the body. This influence is very prominent among children and youths since systematic and programmed physical exercise has a stimulating effect on a young body at the age of adolescence, particularly on proper growth and psycho-physical development (Nikolić, 2005). These kinds of physical activity significantly influence the proper development and normal functioning of internal organs, especially the cardio-vascular and respiratory system, the movement apparatus, the functions of the endocrine system and the organs which take part metabolic processes. All these positive influences of physical activity increase the defense mechanism of the human body. Physical education also has a positive influence on the development of a series of personality features: determination, independence, fine motor skills, agility in time and space, persistence, etc. Physical activity, in addition to having a positive influence on the transformation of human motor skills, influences the development of the esthetic component of proper exercise. In addition to the physical experience, there is also a subjective sense of satisfaction which is manifested through the esthetic component of human movement.

In their research, Helou et al. (2017) wanted to determine that the validity and reliability of the adapted Arabic version of the IPAQ long form was equivalent with the French version used when studying the Lebanese population. The sample participants consisted of 159 students and staff members of the University of Beirut, who had randomly been selected to take part in the study. The indicators of physical activity were derived from the questionnaire and were compared to the body mass index of the participants for validity construction. In the research on the questionnaire's reliability and validity for a Malaysian population performed by Chu & Moy (2015), the questionnaire was administered twice over a period of one week so as to evaluate the reliability of the test. The validity of the criteria was determined between the questionnaire and a seven-day physical activity program. In total, 81 adults participated in the study. The aim of the research carried out by Minetto et al. (2017) was to determine the level of validity and applicability of the long and short form of the Italian version of the questionnaire. The research of Lee et al. (2011) included 23 confirmed studies on the validity of the short form of the IPAQ. Hallal et al. (2010) studied the ten-year use of the IPAQ in Brazil and Columbia.

METHODS

In this research we used the International Physical Activity Questionnaires – IPAQ, which was developed by experts in 1997. This questionnaire was designed to facilitate solving the problem of evaluating the level of physical activity on a global level (Craig, Marshall, Sjostrom, Bauman, Booth, Ainsworth et al., 2003). It refers to the physical activities which are performed during the course of one week. The IPAQ evaluates frequency, duration and intensity of physical activity of adults aged 18 to 65, in four domains: leisure time physical activity; physical activity in the home and garden; physical activity at work, and physical activity during the commute to work.

There is an International Physical Activity Questionnaire Long Form – IPAQ – LF and International Physical Activity Questionnaire Short Form – IPAQ – SF. Research which has been carried out using this questionnaire has indicated that the long form is very adaptable and applicable in all cultures and languages, and that it has an acceptable level of reliability and validity (Hallal et al, 2010, Lee et al., 2011, Helou et al., 2017, Minetto et al., 2017, Kregisar, 2003; Van Holle et al, 2015; Milanović et al, in press). The questionnaire is being used in approximately 70 countries and is available in several languages. It has been proved to be reliable and valid. The questions are structured so that they allow separate scoring for walking, moderate physical activity, and physical activity of high intensity. The calculation of the overall result requires a summation of the duration (in minutes) and frequency (days) of walking, moderate and high intensity physical activity.

The subject matter of the research was a student population of the University of Niš, whose curricula does not include physical exercise as either an obligatory or elective course. The research problem was the evaluation of the level of physical activity of the student population of the University of Niš, which was studied by a questionnaire for the self-evaluation of physical activity (IPAQ – long form). The aim of this research was to determine whether there was a difference in the level of physical activity of the students attending four faculties of the University of Niš whose curricula did not include physical education. The research included students from the Faculty of Philosophy, Economics, Law and Electronic Engineering of the University of Niš. The age of the participants was included in the questionnaire, but the age difference was only one year ± 6 months, and so was negligible, while the duration of study was not determined in the questionnaire. The only studied difference that could have an effect on the level of physical activity among the students was their faculty of choice. The sample of participants in this study consisted of 109 students who attend four faculties of the University of Niš: the Faculty of Philosophy, Economics, Law and Electronic Engineering. The participants were randomly selected and voluntarily agreed to participate in the study, after they had been informed of the idea behind the project which had originated from the Faculty of Sport. The sub-sample of students attending the Faculty of Economics was 30 (age 23 yrs ± 0,6 months), of Electronic Engineering was 30 (age 21 yrs ± 0,6 months), of Law was 25 (age 20 yrs ± 0,6 months) and of Philosophy was 24 (age 22 yrs ± 0,6 months).

All of the students attended only one of the aforementioned faculties, which provides sub-sample independence based on the students' faculty of choice. Once the responses provided by the participants were collected, all of the values were expressed as hours and minutes over the course of one week and converted to values of metabolic equivalents (MET) expressed in hours per week. To evaluate physical activity, the measuring instrument that was used was the IPAQ – long form. The Serbian version of this questionnaire can be found on the site of the Sports and Sports Medicine Association of Serbia (http://www.usms.rs/kontent/stranicy/podaci_i_statistika_ipaq/upitnik.pdf) and the site (http://www.usms.rs/index.php?jezik=la&strana=podaci_i_statistika_ipaq), which is the version used in this research. The research was carried out with the approval of the relevant authorities of the University of Niš. The participants filled out the questionnaire immediately prior to one of their regular classes at their respective faculties in May 2017.

The values for each response given on the IPAQ should be calculated according the criterion provided in this section. After scoring, a numeric value is obtained which allows further data processing. This processing was carried out at the univariate level, with the basic descriptive statistics (arithmetic means, medians, minimal and maximal values, standard deviations). To test the normality of the distribution, considering that each group has fewer than 50 participants, the Shapiro-Wilk test of normality was used. Statistical analyses were carried out using the statistical package SPSS (v. 20), at the level of significance of $p \leq 0.05$.

RESULTS

The aim of this research was to determine whether there were any differences in the level of physical activity of the students from four faculties of the University of Niš whose course curricula does not include physical education classes: the Faculty of Philosophy, Economics, Law, and Electronic Engineering. With the aim of evaluating the alternative hypotheses, the task was to compare the differences in the level of physical activity of students attending different faculties in pairs, which required the use of appropriate techniques for comparing independent groups of participants. Considering the fact that in most cases the hypothesis of the normality of distribution was rejected, the recommendation of the *IPAQ scoring protocol* was that all the indicators be presented as metabolic equivalents (MET) in hours per week, and that all the comparisons be made at the level of the median, as the measure of central tendency. A comparison of the medians proved the better choice due to their decreased sensitivity to extremely small and large values, which was not the case with the average value of the sample. In such cases non-parametric techniques are used, and so to compare the levels of physical activity in this case we used the Mann–Whitney test. This test is used to evaluate the differences between two independent groups on a continuous rating scale. The values of the data on a continuous rating scale are transformed into ranks, and then an analysis is performed to determine whether there are significant differences between these ranks. The measure of central tendency is the median, and not the means of the data, so for this test the actual distribution of the data is not important.

To accept or reject the set hypotheses is a decision made after the statistical processing of the data in a series of steps. At the very beginning, descriptive statistics were determined for all the variables (arithmetic means, medians, minimal and maximal values, standard deviations). Skewness and kurtosis were also used to indicate data distribution. *Skewness* indicates an asymmetric distribution. In the case of a symmetric distribution, the value of this indicator is zero. A negative sign indicates that most of the data is located to the right of the means, while a positive sign indicates that most of the data are located in the smaller value section. The *kurtosis* indicates whether the distribution is platykurtic or leptokurtic. The value of kurtosis for a normal distribution is 3, but most programs are set to calculate a modified kurtosis value, where the value 3 is deducted from the calculated value, which is why positive values indicate a greater leptokurtic distribution, and negative values a greater platykurtic distribution. To test the normal distribution of the data, considering that each group has fewer than 50 participants, the Shapiro-Wilk test of normality was used. Finally we provided a comparison of the levels of activity by using a technique used to determine inter-group differences by analyzing the variance. Just like in the comparison of faculties in pairs, here also the recommended comparison is of medians. For this comparison we use the non-parametric Kruskal – Wallis test. This test is analogous to the Mann – Whitney test, but allows the comparison of several independent groups of participants. The variables which are used to compare the levels of physical activity of the students of the University of Niš are the values of the level of activity expressed as MET hours per week, viewed in four categories of physical activity: activities at work, activities during the commute, household activities (activities in the home and garden) and leisure time activities (recreation, sport and other activities).

If we would like to accept or reject the alternative hypotheses, we should compare, in pairs, the levels of activity of students in various everyday activities (work, commute, household activities, and leisure activities). To test all the alternative hypotheses, we will use the non-parametric Mann-Whitney test. Table 2. provides the values of the medians of the studied groups presented in MET hours per week, as well as the values of the 95% confidence interval for the median and the inter-quartile range which represents the range from the first to the third quartile within which 50% of the data can be found.

Table 1. Physical activity in MET hours/per week

Faculty	Work	Commute	Household activities	Free time	Total
Philosophy	162,6 (19,8-350,4) 254,4	23,1 (16,5-46,2) 31,4	17,9 (9,0-45,0) 36,2	83,8 (23,1-130,8) 116,7	132,8 (72,3-346,8) 304,9
Economics	22,7 (12,4-33,0) /	29,0 (19,8-41,2) 29,7	3,0 (3,0-7,0) 4,0	35,1 (31,1-47,6) 21,5	72,1 (65,2-88,3) 27,8
Law	242,1 (199,6-331,8) 97,4	46,2 (39,6-46,2) 29,7	18,0 (13,0-37,0) 33,0	55,6 (31,6-83,4) 68,0	201,9 (138,9-354,6) 224,15
Electronic Engineering	108,0 (1,3-147,8) 110,8	19,8 (11,6-23,10) 14,9	20,0 (12,0-25,0) 15,9	24,4 (17,2-66,2) 55,7	73,4 (47,9-124,2) 117,3
Entire sample	169,6 (96,0-232,8) 188,1	23,1 (21,6-34,7) 29,7	14,0 (10,5-20,0) 21,0	39,6 (31,6-54,2) 57,3	93,8 (77,5-112,4) 145,4

Legend: In the fields one below the other in the following order we find: the median, 95% confidence interval, interquartile range.

By analyzing the data in Table 1., we can note that the students of the Faculty of Economics are much less physically active at work; however, here we should bear in mind that only two of the participants responded that they were employed, which makes for a very small sample. In addition, we can note that the students attending this faculty are less involved in household activities. The students of the Faculty of Law are more dominant in terms of physical activities at work and in terms of activities during their commute, while the students of the Faculty of Philosophy are more active during their leisure time. This general table leads us to the conclusion that there are differences in the activities that students attending different faculties take part in. As a result, we will further analyze whether these differences are statistically significant. To determine the differences in the level of physical activities of the students, we used the Mann-Whitney test. All the alternative hypotheses will be tested based on the differences in the levels of physical activity in all fields, as well as the levels of overall physical activity.

Table 2. shows the results for the test of the differences in the level of physical activity of the students of the Faculty of Economics and Faculty of Electronic Engineering. The Mann-Whitney test determined that there was a statistically significant difference in the activities of the students attending these faculties in certain fields. The differences can be noted in the activities related to the commute and household activities, while no significant differences were noted for leisure time activities.

Table 2. Differences in the level of physical activity of the students attending the Faculty of Economics and Faculty of Electronic Engineering

Activity	Mann-Whitney U	*p* – value
Work	3,0	,242
Commute	256,0	,006***
Household activities	25,5	,000***
Free time	378,5	,660
Total	409,0	,544

Legend: *,**,***, indicate levels of significance of 10%, 5% and 1%, respectively.

However, even though the level of activities at work is greater in favor of one group, and in household activities in another, and in the overall result, which is viewed on the overall level of activities exhibited by these students, there is no statistically significant difference (U=409,0, p=0,544>0,05). The following comparison is of the students of the Faculty of Economics and Faculty of Law . The results are shown in Table 3.

Table 3. Differences in the level of physical activity of the students attending the Faculty of Economics and Faculty of Law

Activity	Mann-Whitney U	*p* – value
Work	0,0	,032**
Commute	280,5	,107
Household activities	51,5	,000***
Free time	247,5	,046**

Legend: *,**,***, indicate levels of significance of 10%, 5% and 1%, respectively.

The test of the differences in the level of activities of the students of the Faculty of Economics and Faculty of Law indicates that except for activities related to the commute, in all other fields there are significant differences. Furthermore, the test which compares the overall levels of activity also indicates that the difference in the levels is significant (U=79,0, p=0,000<0,01). The results obtained in the analysis of the differences in physical activity among the students of the Faculty of Economics and Faculty of Philosophy are shown in Table 4. The statistical difference which emerges in the levels of activity of the students attending these faculties can be found for their activities in the home and garden. The students of the Faculty of Economics (Md=3, n=17), compared to the students of the Faculty of Electronic Engineering, participate in household activities only a little, and so this difference in relation to the students of the Faculty of Philosophy (Md=17,88, n=22), was here proved to be significant. However, since the differences in the level of activities in other fields did not differ significantly, this activity influences the overall MET scores, and we can conclude that there is a statistically significant difference in the level of physical activity of students of the Faculty of Economics and Faculty of Philosophy (U=209, p=0,009<0,01).

Table 4. Differences in the level of physical activity of the students attending the Faculty of Economics and Faculty of Philosophy

Activity	Mann-Whitney U	*p* – value
Work	3,0	,156
Commute	235,0	,656
Household activities	31,0	,000***
Free time	253,0	,137
Total	209,0	,009***

Legend: *,**,***, indicate levels of significance of 10%, 5% and 1%, respectively.

Table 5. Differences in the level of physical activity of the students attending the Faculty of Law and Faculty of Philosophy

Activity	Mann-Whitney U	*p* – value
Work	24,0	,086*
Commute	154,0	,131
Household activities	273,5	,974
Free time	241,5	,342
Total	241,0	,238

Legend: *,**,***, indicate levels of significance of 10%, 5% and 1%, respectively.

The results obtained in the analysis of the differences in the level of physical activity between the students attending the Faculty of Law and Faculty of Philosophy are found in Table 5.

The students of the Faculty of Law and Faculty Philosophy do not differ significantly in their levels of physical activity. Table 5. contains the test results for all the parts of the questionnaire and it can be noted that all the *p* – values of the tests are greater than 0,05. Only the *p* – value for the test of the differences in the level of physical activity at work is somewhat lower (0,05<p=0,086 <0,1), However, based on the tests of the differences in the overall physical activities, we can see that the differences are not significant (U=240, p=0,238), and so we can conclude that there are no significant differences in the level of physical activity for these two groups of students. The results shown in Table 6. indicate the differences in the levels of physical activity among the students of the Faculty of Electronic Engineering and Faculty of Philosophy.

Table 6. Differences in the level of physical activity of the students attending the Faculty of Electronic Engineering and Faculty of Philosophy

Activity	Mann-Whitney U	*p* – value
Work	21,0	,266
Commute	171,0	,084*
Household activities	265,0	,831
Free time	223,5	,062*
Total	255,0	,068*

Legend: *,**,***, indicate levels of significance of 10%, 5% and 1%, respectively.

Based on Table 6. we can note that the differences in activities at work and household activities for these two groups of students are not statistically significant, while few differences can be noted for the commute and leisure activities. A slight difference in the activities related to the commute can be found in favor of the students of the Faculty of Philosophy (Md=23,1, n=17), compared to the students of the Faculty of Electronic Engineering (Md=19,8, n=29). For leisure time activities the situation is similar. The students of the Faculty of Electronic Engineering (Md=24,38, n=28) are less active during their leisure time than the students of the Faculty of Philosophy (Md=83,8, n=23). In the case of more strict testing (for levels of significance 0,01 and 0,05) these differences would not have any statistical significance, but seeing how it is our goal to note all the differences, the 0,1 level of significance would indicate that the students of the Faculty of Electronic Engineering were still less active than the students of the Faculty of Philosophy. The results shown in Table 7. indicate the differences in the level of physical activity between the students of the Faculty of Law and Faculty of Electronic Engineering.

Table 7. Differences in the level of physical activity of the students attending the Faculty of Law and Faculty of Electronic Engineering

Activity	Mann-Whitney U	p – value
Work	0,0	,001***
Commute	187,5	,002***
Household activities	295,5	,741
Free time	269,0	,149
Total	179,0	,001***

Legend: *,**,***, indicate levels of significance of 10%, 5% and 1%, respectively.

In the overall score there are significant differences in the activity levels. The students of the Faculty of Law (Md=242,1, n=10) are significantly more active at work than the students of the Faculty of Electronic Engineering (Md=108, n=7). The situation is much the same when it comes to the commute of the former (Md=46,2, n=25) who walk more or ride bicycles more than the latter (Md=19,8, n=29). Thus, the students of the Faculty of Law indicate a far higher level of activity compared to the students of the Faculty of Electronic Engineering (U=179, p=0,001<0,01).

DISCUSSION AND CONCLUSION

The alternative hypothesis $X_{1/1}$ – there is a statistically significant difference in the level of physical activity between the students of the Faculty of Economics and Faculty of Electronic Engineering – can be rejected (p=0,544>0,05). Based on the overall level of activity, we can conclude that the alternative hypothesis $X_{1/2}$ – there is a statistically significant difference in the level of physical activity between the students of the Faculty of Economics and Faculty of Law – can be accepted (p=0,000<0,01). The results obtained in the analysis of the difference in physical activity among the students of the Faculty of Economics and Faculty of Philosophy indicate that there is a statistically significant difference in the level of physical activity of the students (U=209, p=0,009<0,01) and that the alternative hypothesis $X_{1/3}$ can be accepted. Having tested the overall level of physical activities we can see that the test is not statistically significant (U=240, p=0,238), and so we can conclude that there are no significant differences in the level of physical activities among the students of the Faculty of Law and Faculty of Philosophy, so the alternative hypothesis $X_{1/4}$ can be rejected. Based on the overall level of activity, we can conclude that the alternative hypothesis $X_{1/5}$ –there is a statistically significant difference in the levels of physical activity among the students of the Faculty of Electronic Engineering and the Faculty of Philosophy – can be rejected (p=0,068<0,01). After stricter testing (for levels of significance of 0,01 and 0,05) these differences would not be statistically significant, but seeing how it is our goal to determine all differences, the level of significance of 0,1 would indicate that the students of the Faculty of Electronic Engineering were still slightly less active than the students of the Faculty of Philosophy. Based on the overall level of activity, we can conclude that the alternative hypothesis $X_{1/6}$ – there is a statistically significant difference in the level of physical activity among the students of the Faculty of Law and Faculty of Electronic Engineering – can be accepted (p=0,001<0,01). Based on the analysis of all the alternative hypotheses we can note that the students of the Faculty of Law, in terms of the hypothesis related to their case, have indicated a higher level of activity at work, while the least active during their commute were the students of the Faculty of Electronic Engineering. In terms of household activities which include activities inside and outside the home and in the garden, compared to the other students, the students of the Faculty of Economics did not show any higher levels of activity. The students of the Faculty of Philosophy indicated higher levels of leisure time activity, but only compared to some faculties.

Significant differences have been noted in all types of activities included in the questionnaire (work *p*= ,004; commute *p*= ,005; household activities *p*= ,000), except for leisure time activities which include recreation and other sports and physical activities (*p*=0,109). Leisure time activities did not show any signs of statistically significant differences among the students of the University of Niš, which indicates that the frequency is evenly distributed and that all the students included in the study actively spend their leisure time. The lack of physical education does not affect the differences between the students attending various faculties of the University of Niš, since in their free time they participate in sports activities which are a part of planned events at their faculties – University Games for the students of Electronic Engineering, Mechanical Engineering, the Law and Economic Sciences, where in addition to a science-specific parts, the students also compete in sports activities. The area in which the University of Niš is located abounds in sports-recreational facilities and centers which offer various services to their users, and students alike. The city Niš is one of the leading centers of elite sports results and the environment itself nurtures the sports spirit of the population in various spheres of recreation and sport, which is one of the motives for students to take part in an active sports life.

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AN OVERVIEW OF THE RESEARCH OF PHYSICAL ABILITIES AND PHYSICAL DEVELOPMENT OF ELEMENTARY SCHOOL STUDENTS

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SUMMARY

The aim of this paper is to present the research in the field of physical development and physical abilities of children of elementary school age, with special emphasis on research in which monitoring and control of physical abilities are determined on the basis of Eurofit battery test in Serbia. Regarding the results of previous research, at a general level it can be concluded that children from Serbian primary schools are still recording the results which indicate that physical fitness fails to follow physical development adequately. Acording to conclusions of recent research, the measures to be taken in order to improve the physical fitness of children should on one hand focus on increasing the efficiency of physical education in schools (the number of hours, improved conditions, availability of school facilities for use, a precise programme and its implementation from the 1st grade of elementary school, increasing the number of extra-curricular physical activities...), and on the other hand improving measures relating to the community and providing better conditions for sport.

Keywords: Anthropomorphology, Children, Eurofit battery test

INTRODUCTION

Anthropo-morphology, the area that deals with the physical characteristics, appearance and structure of the human body and with the status of motor skills, i.e. physical abilities in humans, has been the subject of research for many scientists, both in sport and in rehabilitation and ergonomics, no matter what part of the world they are comming from (Wilsgaard et al., 2005; Janković et al., 2008; Ivanovic, 2014). The studies that analyze the long-term impact of certain lifestyle, the impact of physical activity or inactivity, primarily, health, morphological and physical (motoric) abilities in different population is of agreat significance for this field (Koutedakis & Bouziotas, 2003; Westerstahl et al., 2003; Wilsgaard et al., 2005; Janković et al., 2008; Kallings et al., 2008;). Most of these longitudinal studies, with so-called secular trends and changing tendencies, were mainly published in the last decade. It is also the period when the negative impact of sedentary and urban lifestyle culminated in relation to the mentioned general health status, as well as morphological and physical (motor) skills in different populations. The more frequent presence of obesity in children, as well as the question of inadequate physical activity, is to a large extent a result of the modern lifestyle, i.e., fewer opportunities or requirements for walking and motion, as well as poorer health conditions, including those that relate to nutrition. In developed countries, the issue of low level of physical ability as a consequence of the modern lifestyle has been raised on both the national and global level (Ivanović & Gajević, 2016). The aim of this paper is to present the research in the field of physical development and physical abilities of children of elementary school age, with special emphasis on research in which monitoring and control of physical abilities determined on the basis of Eurofit battery test in Serbia.

METHODS

The study was carried using the methods: literary sources study, document analysis, theoretical analysis and synthesis.

RESULTS WITH DISCUSSION

The system for constant monitoring of physical growth and physical fitness in young and children in Belgrade was implemented in the school year 1972/73, based on decision issued by the City Secretariat for education in Belgrade (Ivanić, 1996) and has been continuously implemented until 1999. It included anually up to 200 thousand Belgrade elementary and secondary school students. Even then, it was sufficient evidence that physical abilities in children and young due to urban/modern lifestyle, i.e. reduced opportunities and need to move, are permanently reduced. At the same time, due to better health and living conditions, including food, in children living in cities (Belgrade) the acceleration of physical development was clearly manifested even then. This disporportion of physical growth and physical abilities in children from Belgrade has created a need for continuous monitoring of physical development and physical abilities with the intention to inform adequate socio-political factors about the situation and tendencies regarding the presented problems in order to take appropriate measures to mitigate them.

In addition, based on comparative analysis of the results from 1973 and 1995, it was concluded that the physical development of the children from Belgrade, aged 7 to 18, still has a positive trend, while physical abilities decreased with age. However, their equivalent ratio, physical abilities to the physical development, is satisfactory only in boys up to 14 years and in girls up to 13 years, and after that age, it declines significantly below the equivalent values of physical development (Dragojević, 1987).

Also, in order to review the state of physical development and physical abilities of the population, as a basis for further research, and in order to determine the tasks of physical exercise, the most comprehensive examination of the population in the Republic of Yugoslavia was conducted back in 1962. The research was conducted on a sample of 68.000 examinees which consisted of school age young population, aged 7 to 19, and the research which included adult working population was conducted in 1964 on a sample of 22.322 examinees of both genders, aged 20 to 55 years. The study results were published by the Yugoslav Institute for Physical Culture.

Since 1987 physical characteristics and motor abilities of students and young have been annually gathered within the Information system in Slovenia (Slofit). System was regulated by school regulations and it includes more than 90% of all students population in Slovenia. Results of extensive research in Slovenia „Longitudinal comparison of the development of certain physical characteristics and motor abilities in two generations of children and young population, aged 7 to 18, in Slovenian primary and secondary schools in the period from 1990-2001 and 1997-2008“ (Strel et al., 2009), show that body weight in students has increased by 4% and the amount of subcutaneously fat depot by 13%. Negative changes were detected in the motor efficiency: in muscular endurance of shoulders and hands area, the results have declined by 15%, in flexibility by 15%. On the other hand, in comparison with the results of other international studies, the Slovenian research revealed positive trend of trunk muscle endurance by 6% (as a result of promoting „the cult of beautiful bodies“ through the television and by promoting home exercise using different new devices). It was concluded that, in addition to good professional and technical conditions for engaging in sports and physical activities in Slovenia, there is still necessity to improve and promote an active lifestyle, to increase physical activity and promote healthy eating habits on global – state level. Also, Slovenian scientists believe that the extremely rapid increase of negative effects on the physical fitness level in young Slovenian could be stopped if two hours, instead of formerly recomended one hour of physical activity per day, were practised, adapted to the different children's needs and interests (Strel et al., 2009).

Today data on physical abilities of children and young population are collected worldwide, by using various systems. It is considered and it is scientifically proven (Sauka et al., 2011; Keane et al., 2010) that the level of physical fitness is an excellent indicator of the health of children and adolescents and that continuous monitoring and controling of physical fitness should be considered a public health priority. There are currently more than fifteen battery (group) tests in the world for the assessment of physical fitness in children and adolescents. The most common test battery in the United States for measuring motor skills of young people is FITNESSGRAM, in Slovenia abovementioned SLOFIT, in many European countries and beyond – in Australia for example, the most common testing battery is EUROFIT.

EUROFIT comprises a test battery for the assessment of general (not specific) physical fitness in children from 7 to 18 years of age and was devised as a result of long-time coordinated work of European researchers (from 1977 to 1990) for long-term needs in the field of recognising the effective ways for carefull assessment the physical fitness in children and young and their achievements in the field of physical ability in order to develop health, physical education and sport within national boundaries. In this sense, EUROFIT provides greater unity among the researchers and the possibility for the assessment of physical fitness in children, and health status can be more unified in the European countries and beyond, leaving the relevant institutions to design national test batteries, such as SRBIJAFIT in Serbia. The structure of EUROFIT test battery, which is used in European countries for the assessment of FITNESS (the term fitness is widely accepted for physical ability, originated as an acronym from = F - frequency, I - intensity, T - time and T – type of activity) of children and adolescents, designed for the assesment of general physical fitness of general population, and with the aim to assess physical fitness in regard to health and involving in recreational sport, it was not aimed to proffessional sport (Council of Europe, 1993). It was designed to measure: maximal aerobic consumption, muscle strength and its endurance, mobility, balance and speed.

Certainly the greatest importance of Eurofit test battery is in its ability to assess the health status and physical ability in children of school age (Michaud et al., 1999; Deforche et al., 2003; Ekblom et al., 2005; Eminović and Gajević, 2011; Sauka et al., 2011), which is its main role. As already stated in the introduction, the question of rising obesity in children as well as their inadequate physical ability is recognised as an important issue. Despite all the efforts, 2 to 3 classes of physical education cannot fully satisfy the need for physical activity, which animate a large number of experts to join the fight against obesity (Ivanović & Gajević, 2013, 2016). The group of Greek authors (Christodoulos et al., 2006) concluded that the additional 30 minutes of physical activity every day is an excellent way to prevent obesity. These conslusions were made based on research conducted on a sample of 178 children of school age. Morphological characteristics, with special attention to obese children, as well as physical ability, were monitored during the school year and after the return of children from summer holidays. Ahmedov and his associates (Ahmedov et al., 2006) tried to explain the issue of obesity, the causes of the origin in relation to the physical fitness, who monitored children aged 9 to 11 from different regions in Cyprus. The study comprised 7425 children and the obtained results showed that children from rural areas have the higher level of physical fitness compared to their peers from urban parts of the state. They also had a smaller percentage of fat mass in averall body mass.

In order to different physical abilities and activities in children with obesity issues and those who have no such problems, Deforche and his associates. (Deforche et al., 2003) tested 3214 young Flemings. It was found out that the children who were overweight, had lower scores in all tests that involved manipulating their own body weight, but generally did not fall behind other children regarding the values of fitness index. As one of the possible conclusions based on the results, was the need to adapt the physical activity to the abilities of obese children.

Eurofit test battery is often used to define morphological and physical status in the function of gender. In the study of Gajević and associates (Gajević et al., 2010), it was stated that there were no statistically significant differences within the morphological characteristics between boys and girls from 7 to 14 years, while whithin motor space, boys have achieved better results in almost all measurements (girls recorded better test results only in flexibility test in the ages 8, 11 ,12, 13 and 14).

The research results of Ekblom and associates (Ekblom et al., 2005) showed a higher level of physical fitness in boys than in girls, as well as the increase of that level with growth and development. The study included 1737 children from Sweden, age 10, 13 and 16. Michaud and associates (Michaud et al., 1999) conducted a similar study on children from the canton Vaud in Switzerland. They were, in addition to data on fitness level, collecting data on their physical/sports activities. The sample consisted of 3540 children aged 9 to 19. The results showed that the majority of the examinees is engaged in some sport activity, but that the boys are far more engaged in comparison to their peer. Participation in sports activities decreases after the age of 15, especially in girls. Authors conclude that programs and strategies with the aim to increase physical activity, must be directed primarily towards gender (girls) and then to groups over 15. One of the biggest research was conducted by Sauka and associates (Sauka et al., 2011). In a sample consisting of 10464 children in Latvia aged 6 to 17, it was concluded that boys achieved better results in tests of muscular endurance, strenght, cardiorespiratory endurance an speed, while girls achieved better results in tests for the flexibility assessment. Also, the more pronounced trend changes was established in boys than in girls.

Pilot study Determination of the physical fitness in children of school age in the Municipality of Čukarica (Gajević, 2009) is part of the Project „Monitoring the physical fitness in children of school age in the Republic of Serbia“, which the Institute of Sports and Sports Medicine has implemented during 2009.

The sample consisted of 878 students (456 boys and 422 girls) in primary school from the Municipality of Čukarica. All students were measured using EUROFIT test battery, prescribed by the Committee for the Sport Development of Council of Europe. Elaboration of data obtained from the survey of transversal character, the facts author summarized by the following conclusions (Gajević, 2009):

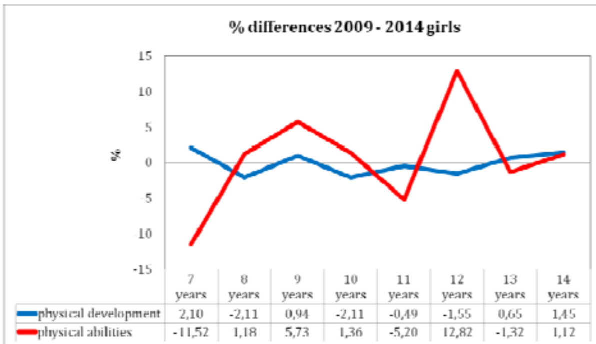
1. The results of research within the area of physical development

The obtained results categorically show that children of primary school age are higher than in 1995 (in children aged 7 to 14 body height increased in average by 3% in boys, and in girls by 2,5%). In addition, for the same period, body weight of primary school children increased in average by 14% in boys, and by 11% in girls. The values of body mass index increased in average by 7.3% in boys, and by 5.6% in girls. Based on these indicators, author concluded that primary school children in the last decade had been subjected to huge constitutional changes, particularly within the variables body weight and body mass index (BMI), which increased significantly in comparison with the values from 1995. Also, compared to the results regarding the children of school age from other European countries, it is obvious that primary school children in the Republic of Serbia recorded values above the average within the results related to all three variables that characterized the physical development in both genders.

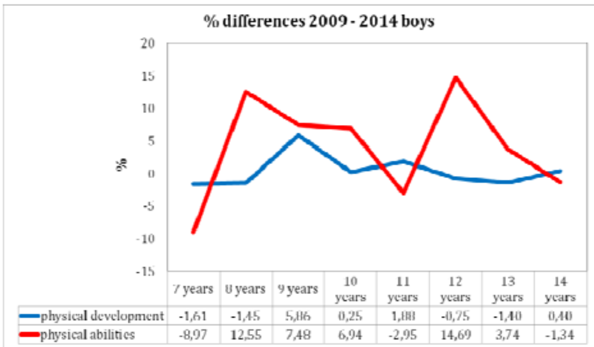
2. The results of the research within the motor space

Data obtained in this area, indicated a complete inverse character of physical capacity in relation to the physical development. While physical development recorded progress in the above mentioned terms, physical abilities were characterized by a decrease of average values in relation to the results from 1995, by 6% in average in boys, and by 12% in girls. Compared to the results of children of school age from other European countries, it is obvious that the results of children in the Republic of Serbia within parametres of physical fitness covered by the Eurofit test battery were under the average.

Second study of the same authors (Ivanović & Gajević, 2016) presents a comparative study of transversal type in children aged 7 to 14, extracted from the population of elementary school children. The total sample of examinees was 839 students (424 boys and 415 girls) measured in 2014 and 848 students (456 boys and 422 girls) measured in 2009. All students were measured using Eurofit Test Battery with the same procedures and equipment prescribed by the Commission for the Sport Development of Council of Europe. At the level of total sample in function of age testing and trend changes, the results showed tendency of changing observed characteristics of physical fitness in relation to the initial stratum in both samples (boys and girls) measured in 2009. Regarding the results obtained using comparative analysis of current testing and previous researches, at a general level authors concluded that children from Belgrade primary schools are still recording results which indicate that physical fitness doesn`t follow adequately physical development (Graphs 1, 2).



Graph 1. Differences within girls



Graph 2. Differences within boys

CONCLUSION

The significance of this research was originated from the fact that quantifying and systematic monitoring of physical development and physical fitness provides multiple opportunities for creating databases, setting norms for comparison of the whole generation of students, and each of them individually, comparison and analysis of the results of the same population in our country and in the world, check the test battery and finally basis for adoption of appropriate strategic measures of planning and developing character in the field of physical education.

At this point, based on result of previous research, the precise reason for the determined differences and trend changes for the characteristics of physical fitness in children of primary school age cannot be assessed. As a conclusion of authors of previous research, it is not possible because numerous factors were not covered in the course of that research, for example:

- Number of physical education classes,
- The structure and efficiency of the physical education programme,

- Extra-curricular physical activities,
- Other social or personal factors.

Regarding the results of previous research, at a general level it can be concluded that children from our primary schools are still recording results which indicate that physical fitness does not following physical development adequately. Acording to conclusions of recent research, the measures to be taken in order to improve the physical fitness of children should on one hand focus on increasing the efficiency of physical education in schools (the number of hours, improved conditions, availability of school facilities for use, a precise programme and its implementation from the 1st grade of elementary school, increasing the number of extra-curricular physical activities, and so on), and on the other hand improving measures relating to the community and providing better conditions for sport.

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GENERALIZATION OF THE FORCE-VELOCITY RELATIONSHIP PARAMETERS OBTAINED FROM BOTH THE BENCH-PRESS THROW AND SQUAT JUMP WITH DIFFERENT TYPES OF LOADS

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SUMMARY

The aim of this study was to examine the possibility of generalizing the parameters of the force-velocity (F-V) relationship obtained from the Bench-press throw (BPT) and Squat Jump (SJ) with gravitational (W), inertial (I) and combined (W + I) type of load. The generalization possibility was investigated through the correlation analysis of the linear F-V relationship parameters, such as maximum force (F_0), velocity (V_0) and power (P_{max}) that have been obtained from BPT and SJ within the same type of loads. The study involved 15 male subjects who performed BPT and SJ on the same Smith machine, with 5 different loads (40 kg to 80 kg) at W, I and W + I types of loads. The results of the study indicate that in relation to different motor tasks performed by arms and legs in conditions of application of different types of loads, there is a difference in the correlation between the F-V relationship parameters and that the possibility of generalization is relatively limited. Namely, the muscular capacities estimated through the F-V relationship obtained with the motor task of the arms can be generalized only in relation to the estimated leg muscle capacity for F_0 at W ($r = 0.673$ **), and for P_{max} at I ($r = 0.524$ *). Although the assumption was that the performance of multi-joints straight-line movements with low degrees of freedom, which allows a large load range and maximum speed of execution, on the same Smith machine, in standardized conditions (angles, loads) and the same methodology, with the same respondents, at W, to make such a possibility for both V_0 and I, as well as P_{max} at W + I, this did not happen. Future studies should examine the possibility of generalization with completely uninformed respondents (or rather highly specialized respondents) and with the same training history.

Keywords: generalization, F-V relationship, gravitational load, inertial load, force, velocity, power.

INTRODUCTION

Managing the training process has become dependent on the information on which the training plans and programs are based with necessary update. The economics of controlled factors that success depends on becomes a new important aspect in the training process. With this regard, the recent studies that investigated the linearity of force-velocity (F-V) relationship proposed the novel method of testing which is increasingly applied. Namely, it has been shown that it is sufficient to apply only 2 different loads for valid, reliable and sensitive assessment of the force (F), velocity (V) and power (P) (Zivkovic, Djuric, Cuk, Suzovic, & Jaric, 2017a). Keeping in mind the importance of force, velocity and power in modern sports, the practical applicability of the evaluated novel methodology is obvious.

The modern training approach considers the application of different types of loads. Namely, in addition to the combined (W + I) type of load (i.e., the weight lifting), the longer elastic rubber bands are extensively used providing both positive and negative loads. The recent studies have shown that the selective application of gravitational (W) or inertial (I) types of loads has the better effects on improving the muscle ability to produce the force or velocity, than the application of the usual W + I type of load (i.e., lifting the weights; Djuric, Cuk, Sreckovic, Mirkov, Nedeljkovic, & Jaric, 2016).

The above mentioned suggests that the modern training requires the improved methods of physical performance testing. Since it has been shown that the parameters obtained from the linear F-V relationship could be valid and reliable predictors of various muscle mechanical properties further investigation of this phenomenon is necessary. The logical next step is to examine the question of the possibility of generalizing different muscle groups through F-V relationships obtained on different types of loads. The literature review indicates relatively small possibility of generalization through different muscle groups. Namely, in one study such a possibility was limited (Zivkovic, Djuric, Cuk, Suzovic, & Jaric, 2017b), while other authors proposed separate testing of arms and legs (Giovani & Nikolaidis, 2012; Nikolaidis, 2012; Nikolaidis, Fragkiadiakis, Papadopoulos, & Karydis, 2011). However, taking into account the methodology of the above research, the assumption in this study was that a greater possibility of generalization would be obtained if the same subjects would be tested on the same Smith machine under the same conditions (i.e., motor task is performed along the straight line with low degrees of freedom) which allows large load range and maximum execution speed. Therefore, the aim of this study is to investigate the possibility of generalizing the parameters of linear F-V relationship obtained by performing BPT and SJ with W, I and W + I type of load. Note that the possibility of generalizing the parameters of the F-V relationships was not examined on W or I types of loads. We hypothesized that the highest correlations between the parameters obtained from BPT and SJ will be recorded when F, V or P parameters are calculated from W, I or W + I types of loads, respectively.

METHODS

Subjects

15 students of the Faculty of Sport and Physical Education participated in this study (age: 20.9 ± 2.0; body weight: 82.5 ± 5.9 kg; body height: 185.2 ± 4.9 cm; % of body fat: 10.1 ± 4, 2%; BMI: 24.0 ± 1.6 kg/m^2). The inclusion criteria were 100 kg (± 10 kg) in 1RM of bench-press (BP), as well as 140 kg (± 10 kg) in 1RM of semi-squat (SS). During the duration of the experiment, the subjects were physically active through the standard academic curriculum with at least 6 hours per week.

Procedure

The tests were performed on a modified Smith machine during 5 sessions with 3 days rest. During the 1st session, the anthropometry (i.e., body height and body mass, as well as body composition) was measured. 1RM in BP and SS was assessed during the 2nd session, as well as subject's familiarization with BPT and SJ at W, I and W + I. During the next 3 sessions, the subjects were tested on BPT and SJ with 5 different load intensities in a random order where the type of load was also randomly varied. The sessions started with standard 5 minutes warm-up procedures including bicycle riding as well as whole body exercises.

During BPT testing, the subjects laid down on a flat bench holding the bar a 1 cm above the chest, while during SJ the bar was rested on a shoulder with the knee bended at a 90° angle. The initial positions of the subjects, as well as the concentric mode of muscle contraction, have been possible by adjusting the height of the bar support to each subject separately. The referent mass of a bar was 20 kg and it was hold constant through different types of loads. The weights and / or elastic rubber bands equivalent to weights were added to the referent mass of a bar (i.e., 20+20 kg, 20+30 kg, 20+40 kg, 20+50 kg and 20+60 kg), which was approximately 40% to 80% of 1RM in BP and 28% to 57% of 1RM in SS. Two attempts have been performed at each intensity. The pauses were 1 minute between attempts at the same intensity and 4 between different intensities. When W type of load had to be assessed, the elastic tires were applied instead of weights, which forcefully pulled downwards the bar in order to imitate the force of gravity. On the other hand, when I type of load had to be assessed, the elastic tires were applied in addition to the weights, which forcefully pulled the bar upwards in order to cancel the force of gravity. Finally, when W + I had to be assessed, the weights were added to the bar. The graphical presentation of the tests with different types of loads is shown in Figure 1.

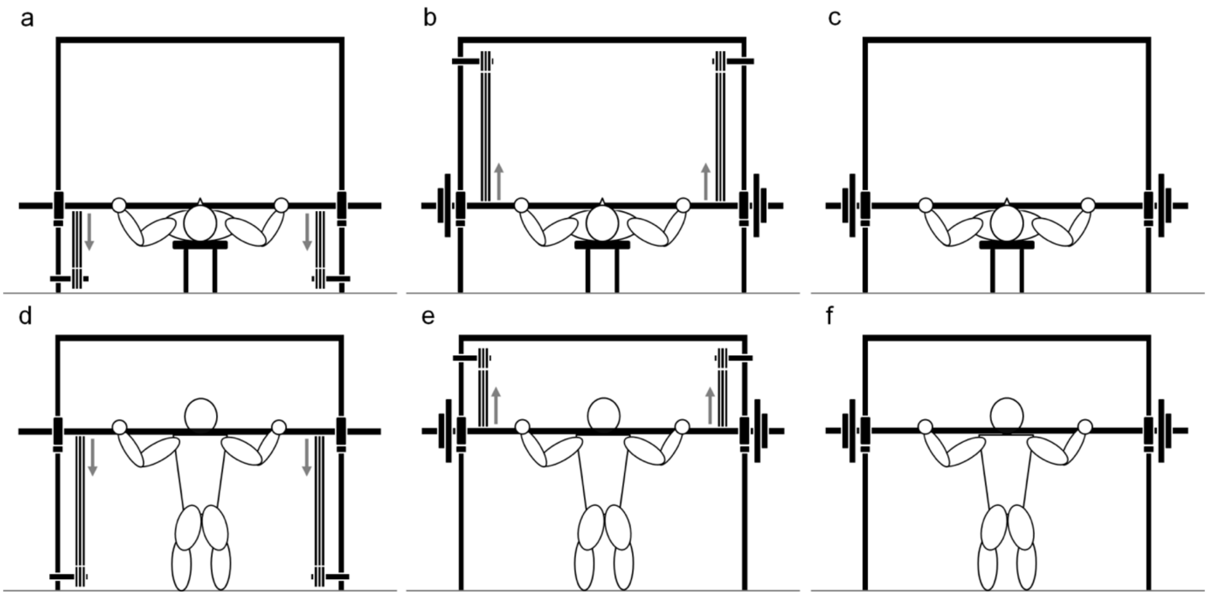

Figure 1. Display of the starting position in both Bench-press throw (BPT; upper panels), as well as Squat-jump (SJ; lower panels) with gravitational (left panels), inertial (middle panels) and combined (right panels) type of load.

For the purpose of simulation of W and I type of load, the standard Smith machine was modified by an additional construction consisting of a metal frame, plastic coils and 6 elastic rubber bands which length was 14 m (three pairs of elastic rubber bands on each side of the bar). One side of the elastic rubber bands were hooked to the bar (the moving end), then went through the system of the coils (7 or 6 depending on the type of load) and were fixed on the other side through the rope brakes. Before the start of the test, the elongation of the elastic rubber bands was calibrated according to the required force production (the coefficient of elasticity is 7.0 N / m). The length of the elastic tires was sufficient so the relatively constant pulling force during the BPT and SJ was provided. The Figure 2a shows the construction used in order to simulate W type of load in BPT. The Figure 2b shows the same construction, but with slightly changed design (the elastic rubber bands were attached from the upper side of the bar) that simulates I type of load in BPT. The same principle was applied to the SJ testing.

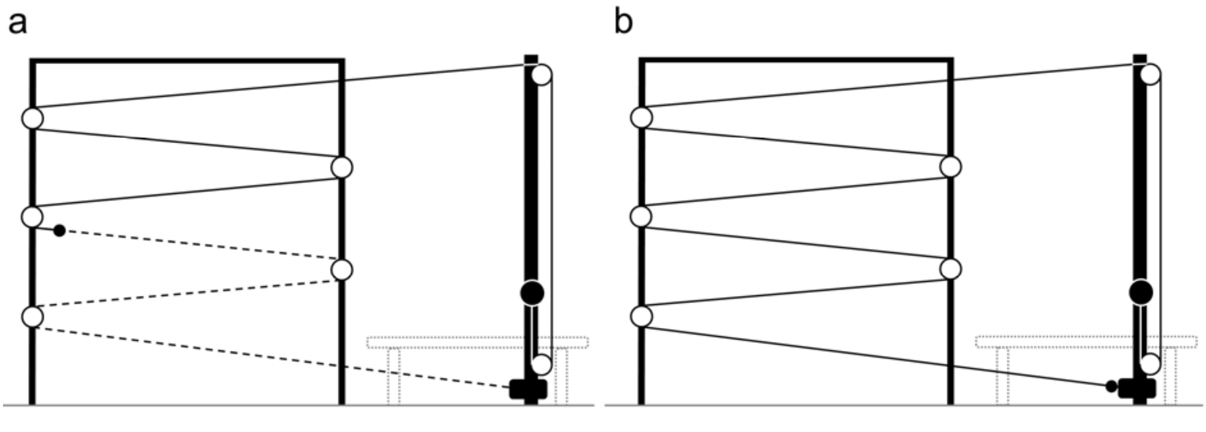

Figure 2. The modified Smith machine and the additional construction for simulating the gravitational type of load in Bench-press throw. The elastic rubber bands are shown at the minimum (Figure 2a, the elastic rubber bands are represented by a full line, and the added rope with a dashed line) and at the maximum (Figure 2b) of the stretch.

The vertical movement of the bar was recorded by using the infrared cameras for 3D kinematics analysis. The specially designed LabVIEW software was used to determine the variables F and V from BPT and SJ.

Statistical analysis

The application of Kolmogorov-Smirnov test confirmed the normal distribution of data. In order to check the possibility of generalizing the obtained results in BPT and SJ, separately for each type of load, Pearson's correlation analysis (Hopkins, 2000) was used.

RESULTS

Table 1 shows the parameters of individual linear regression obtained in BPT and SJ at W, I and W + I.

Table 1. Parameters of individual linear regression obtained in Bench-press throw and Squat-jump by using three different types of load.

Task	Type of load	F_0 (N)	V_0 (m/s)	P_{max} (W)	r
Bench-press throw	Gravitational (W)	917 ± 51	2.1 ± 0.2	501 ± 46	0.978 ± 0.013
	Inertial (I)	848 ± 92	3.0 ± 0.3	648 ± 66	0.976 ± 0.017
	Combined (W+I)	972 ± 45	2.5 ± 0.3	604 ± 67	0.983 ± 0.013
Squat-jump	Gravitational (W)	1917 ± 197	4.8 ± 1.0	2274 ± 472	0.963 ± 0.030
	Inertial (I)	2272 ± 296	3.9 ± 0.9	2192 ± 446	0.930 ± 0.035
	Combined (W+I)	2194 ± 193	4.4 ± 1.5	2396 ± 663	0.934 ± 0.063

The data are shown as mean values and standard deviations.

The results shown in Table 2 indicate that the high and significant correlation coefficients between the same parameters obtained in BPT and SJ were observed only between the parameters F_0 at W, or between P_{max} at I.

Table 2. Correlation coefficients of the parameters of F-V relationship obtained in Bench-press throw and Squat-jump by using three different types of load.

Type of load	F_0	V_0	P_{max}
Gravitational (W)	0.673**	0.039	-0.060
Inertial (I)	-0.319	0.073	0.524*
Combined (W+I)	0.134	0.476	0.460

The data are shown as correlation coefficients (r) of the parameters of force-velocity relationship between the Bench-press throw and Squat-jump, separately for each type of load. (** $p < 0.01$; * $p < 0.05$)

The main finding of the present study indicates that high and significant correlation at W type of load was observed only between F_0 (r = 0.673 **; $p < 0.01$) obtained in both BPT and SJ, while among other observed parameters (i.e., V_0 and P_{max}) there is no significant correlation. On the other hand, high and significant correlation at I type of load was observed only between P_{max} (r = 0.524*; $p < 0.05$). At W + I type of load, the correlation between the parameters was moderate (V_0; r = 0.476 and P_{max}; r = 0.460) to low (F_0).

DISCUSSION

The aim of this study was to examine the possibility of generalizing the parameters of F-V relationship obtained in BPT and SJ at W, I and W + I types of loads. This study is probably the first one that takes into account different motor tasks performed on same subjects and with the same testing methodology that uses different types of loads.

Contrary to what was expected, the obtained results proved to be rather inconsistent indicating that the possibility of generalization is limited to W + I, and relative to W and I. In other words, it has been established that the muscle capacities estimated through the F-V relationship can be only partially generalized with respects to the muscle capacity of the legs, and for this reason the proposed hypothesis could be accepted only partially. Namely, when a combined load type has been applied, a moderate relationship between the obtained parameters V_0 and P_{max} was observed, while the relationship between the parameter F_0 was weak. These results are in line with previous findings (Zivkovic et al., 2017b). Note that there is a slightly difference to the results of this study with regards to parameters V_0 that have proved to be a stronger in our study, which can be explained as a result of an increased load range that provides a more direct assessment of parameters V_0 instead of being the result of remote extrapolation. However, it should be kept in mind that the notable moderate possibility of generalizing the parameters of F-V relationship may be in line with recent studies that reveal a weak possibility of generalizing the results obtained by the individual muscles (Bohannon, Foster, Pierce, Pilkiewicz, & Schmitt, 2008) or functional movements (Pojednic et al., 2012). It is important to note that different variables obtained by using different methods can highly correlate with the same muscle, but low in relation to the muscular system in general (Bozic, Celik, Uygur, Knight, & Jaric, 2013; Prebeg et al., 2013). Similar findings were obtained by other authors, who therefore propose to test separately arm and leg muscle mechanical properties (Giovani & Nikolaidis, 2012; Nikolaidis, 2012; Nikolaidis et al., 2011).

Regarding the generalization of the parameters obtained by using W type of load, a weak mutual relationship was observed, except for F_0, which is high and significant. Such results could be expected considering that the results of W type of load depend on strength of the subjects that is mostly under the influence of training. Namely, although the subjects used to practice various sports, the assumption is that in a particular period of preparation within their training history, there were non-specific whole-body exercises that were performed in order to improve general power and force. On the other hand, speed development was characterized only for speed related sport such as sprint. Moreover, it is important to emphasize that speed is more genetically determined so the training produced differences are less prominent. Therefore, due to the above listed reasons, it is possible that the subjects' training history could have an impact on increasing the overall level of strength (regardless of the specialization of certain extremities), without affecting the general level of velocity. Therefore, the possibility of generalizing the force in the W type of load is increased, while the possibility of generalizing the velocity is decreased in either type of loads.

On the other hand, the generalization of P_{max} could be possible only with I type of load. This can be explained by the fact that the greatest output of power is precisely when working with its own weight, and I type of load is - in this case - the most similar to the work without any additional load. Namely, the findings of the recent studies indicate that the weight of one's own body represents an optimal load for generating a maximum mechanical output in vertical jumps (Markovic & Jaric, 2007). Namely, the leg muscles are mainly designed to allow maximum dynamic output in fast movements performed against the weight and inertia of one's own body (Jaric & Markovic, 2009). Despite the fact that these findings have been obtained on leg muscles, this might explain the highest correlation of parameter P_{max} obtained in BPT and SJ with I type of load.

CONCLUSION

The findings of the present study indicate that the muscular capacities estimated through the F-V relationship obtained in arm tasks can only be partially generalized when compares to the muscle capacity of legs. Specifically, the generalization is only possible for F_0 at W and P_{max} at I. Based on these findings, it could be suggested that future research should be conducted on completely untrained (or even highly specialized) subjects. Namely, one of the possible reasons for this inconsistency, as well as the possible limiting factor of this study, could certainly be the nature of the subjects' history. General preparation or, on the other hand, specialization due to training could contribute to the different development of force in the muscles of the arm or leg, and therefore also affect the possibility of generalizing the capacity of muscular properties.

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FOOT STATUS IN THE POPULATION OF STUDENTS OF THE UNIVERSITY OF NIŠ

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SUMMARY

The aim of this study was to report the prevalence of flat foot and difference in relation to the gender and engagement in sports, among healthy and fit adolescents. In data processing, descriptive statistics and non-parametric statistics was used, i.e. Hi^2 test (cross tabulation analysis 2x2). The sample of subjects included 128 adolescents (92 males and 36 females), students of the University of Niš aged between 20-23. In relation to gender, the prevalence was 42.4% for left Pes Planus (PP) and 33.7% for right PP, respectively in the male students. For the female students, the prevalence was 22.2% for left PP and 19.4% for right PP, respectively. In relation to sports engagement, the prevalence was 39.1% for left PP and 21.74 for right PP, respectively in the non-athletes. For athletes, the prevalence was 35.4% for left PP and 34.2% for right PP, respectively. Statistical significance in all evaluated variables is at the level of significance greater than 0.01, so it can be concluded that the achieved deformity rates of the foot (in male and female students or in athletes and non-athletes) do not differ statistically from the theoretical frequencies, neither by gender, nor by engagemnet in sports.

Keywords: Pes planus, adolescents, prevalence, differences

INTRODUCTION

Flexible flat foot is a normal observation in typically developing children (Banwell, Paris, Mackintosh, & Williams, 2018). However, if the spontaneous development of the arches of the foot is not realized during the childhood, some symptoms or disabilities can be transferred and reflected in adolescence and adulthood. Arches of the foot plays a major role in walking, running and jumping. Foot arches are supported by various ligaments and muscles, among that tibialis posterior is one of the major muscle which maintains the integrity of the foot arch structure (Vijayakumar, & Kumar, 2017). Tibialis posterior accounting for 75% of arch integrity and stiffness of the medial longitudinal arch (Huang, Kitaoka, An, & Chao, 1993).

The aim of this study was to report the prevalence of flat foot and difference in feet status in relation to the gender and engagement in sports, among healthy and fit adolescents

METHODS

Subjects

A total number of 128 adolscents (92 males and 36 females, i.e., 46 non-athletes and 82 athletes), students of the University of Niš aged between 20-26 are volunteered to participate in this observational type of study. Athletes were engaged in different sports (athletics, Brazilian jiujitsu, judo, fitness, folk dance, football, gymnastics, karate, basketball, crossfit, volleyball, dance, swimming, handball, tennis, art swimming, waterpolo), at least for one year.

Procedure

Computerized scanner equipment, Pedicom (Hungary) was used in evaluation of the feet status. Individuals stood over the toghened glass of the equipment and the scanning procedure was done. The scanned plantar surface images are then transferred to the computer and the feet status was measured using integrated Pedicom software.

Statistical analysis

In data processing, descriptive statistics and non-parametric statistics was used, i.e. Hi^2 test (Cross Tabulation Analysis 2x2). Results are presented descreptively, i.e., by tables and figures.

RESULTS

In relation to gender, the prevalence was 42.4% for left Pes Planus (PP) and 33.7% for right PP, respectively in the male students. For the female students, the prevalence was 22.2% for left PP and 19.4% for right PP, respectively.

Table 1 Prevalence of PP in relation to gender

		Left Foot		Right Foot		Total
		Normal	Pes Planus	Normal	Pes Planus	
Gender	Males	53	39	61	31	92
	Females	28	8	29	7	36
	Total	81	47	90	38	128

Table 2 Differences in prevalence of PP in relation to gender

Chi-Square Tests	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square (Left Foot)	4,530	1	,033
Pearson Chi-Square (Right Foot)	2,518	1	,113

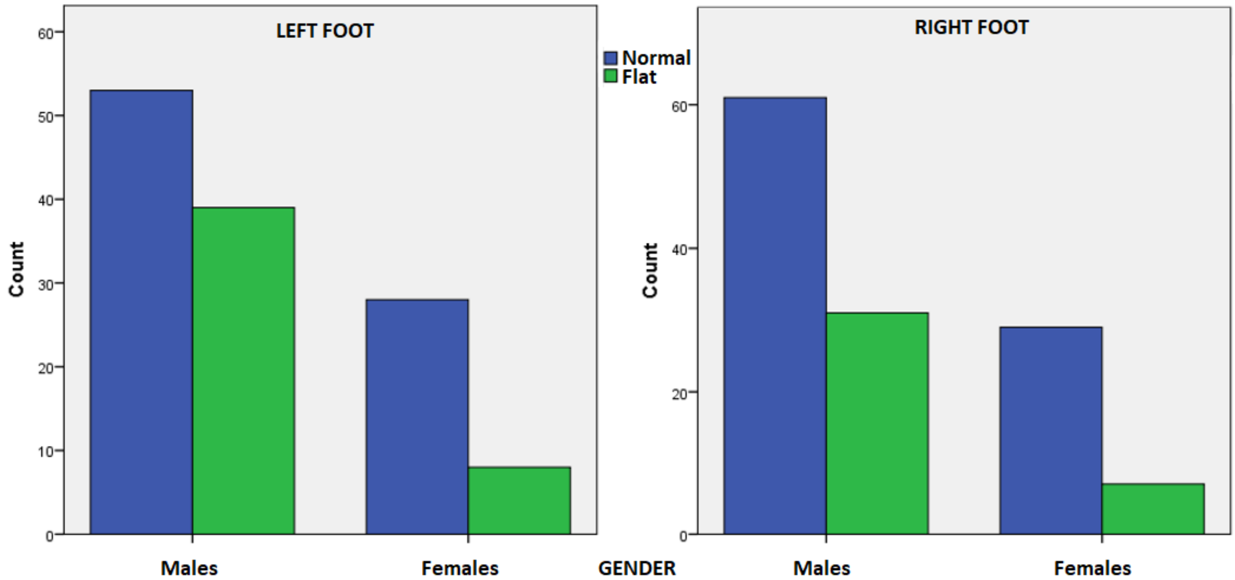

Fig. 1 Prevalence of PP in relation to gender

In relation to engagement in sports, the prevalence was 43.5% for left PP and 21.8% for right PP, respectively in the non-athletes. For athletes, the prevalence was 35.4% for left PP and 34.1% for right PP, respectively.

Table 3 Prevalence of PP in relation to engagement in sports

		Left Foot		Right Foot		Total
		Normal	Pes Planus	Normal	Pes Planus	
Engagement in sports	Non-athletes	26	20	36	10	46
	Athletes	53	29	54	28	82
	Total	81	47	90	38	128

Table 4 Differences in prevalence of PP in relation to engagement in sports

Chi-Square Tests	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square (Left Foot)	0,180	1	,672
Pearson Chi-Square (Right Foot)	2,173	1	,140

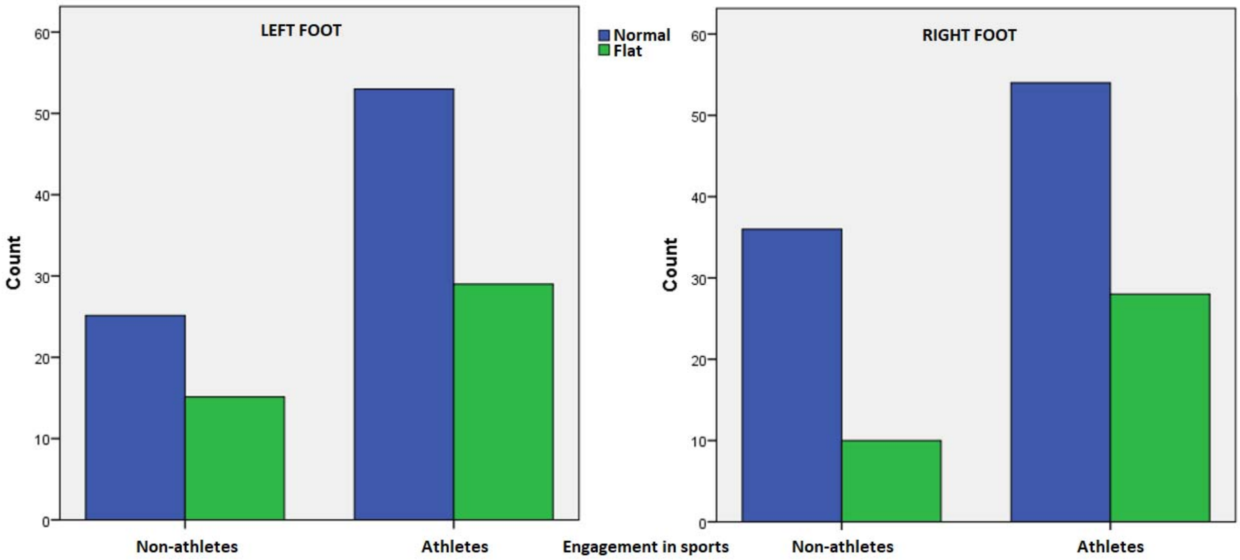

Fig. 2 Prevalence of PP in relation to engagement in sports

Statistical significance in all evaluated variables is at the level greater than 0.01, so it can be concluded that the achieved deformity rates of the foot (in male and female students and in athletes and non-athletes), do not differ statistically from the theoretical frequencies, neither by gender, nor by engagemnet in sports.

DISCUSSION

Foot posture is a controversial issue (Morrison, McClymont, Price, & Nester, 2017). There seems to be lack of the consensus on how this frequently observed foot type should be evalueted, defined or assessed. However, there is a consensus that a flat foot posture outside of expected norms may not require management. This study is limited by the fact that the inclusion criteria were foot posture measures calculated from the computerized plantongram, only. Uden, Scharfbillig, & Causby (2017) pointed out that categorising the foot posture based on footprint data doesnt reflect the complexity and multi-planar motion of the foot. Recent paediatric based studies pointed out on significant difference between static structure (whith feet in bipedal weight-bearing relaxed stance) and dynamic foot function (Barisch-Fritz, Schmeltzpfenning, Plank, & Grau, 2013). Future studies on this topic are about to be beneficial.

CONCLUSION

Obtained data are worrying, signaling on great prevalence of flat foot in the student population of the University of Niš, that is greater in males than in females, and in athletes than in non-athletes. Computerized scanner equipment, Pedicom (Hungary) confirmed itself as good screening tool.

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THE EFFECTS OF A SIX-MONTH INDIVIDUAL EXERCISE PROGRAM OF A BLIND CHILD – A CASE STUDY

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SUMMARY

The aim of the study is the effects of a six-month individual exercise program onto body composition, postural disorders and physical deformities of a blind child. The sample of the respondents is a blind boy (A.T.), aged 10. Assessment of the body composition has been followed through parameters: body weight, skeletal muscle mass, body fat, body mass index, body fat percent, body height, segmental analysis, intracellular and extracellular fluids, basal metabolism, childhood obesity rate and bone mineral content. Postural disorders and body deformities have been followed through parameters: the angle of the kyphotic curve, the angle of the lordotic curve, the angle of the scoliotic curve in the thoracic region, and the angle of the scoliotic curve in the lumbar region. The individual exercise program was carried out in the duration of six months, three times a week. The parameters of body height, body weight and skeletal muscle mass were numerically increased at the final measurement compared to the initial, while fat mass values were numerically lower; the body mass index and percentage of body fat were numerically lower at the final compared to the initial measurement. In the assessment of the body composition of segmental tissue analysis, there was a numerical increase in value in all body segments. Obesity indicators have been numerically decreased between the two tests, while basal metabolism, bone minerals, intracellular and extracellular fluid values have been numerically increased. It is thus concluded that the effects of a six-month individual exercise program of a blind child onto body composition, postural disorders and physical deformities are positive.

Keywords: individual exercise program, blind child, case study, body composition, physical deformity

INTRODUCTION

People with visual impairments who have physical activities, compared to those who do not, have a much better structure of body composition (Augestad & Jiang, 2015). In children with vision impairments who do not have sufficient physical activities, a lower level of general health components and body composition has been observed. Persons with minor visual impairments have physical activities more frequently and have a better body composition than those who are completely blind (Holbrook et al., 2009).

Absence of vision leads to disturbance of the proper body posture due to inadequate interaction with the environment and affects normal patterns of walking and balance, and in order to compensate for the improper body posture and walking, postural abnormalities are further developed (Alotaibi et al., 2016). Vision is important for the development of postural reflexes, and loss of vision can also affect the body mechanics. A blind child develops abnormal postural reflexes and defective motoric patterns, which may lead to an irregular distribution of muscular power throughout the body and to a rapid disruption of posture and balance. This further favours the creation of physical deformities with the blind child (Giglio & Volpon, 2007).

In order to approach the physical exercises of persons with visual impairment, it is necessary to bear in mind (Grbovic, 2005): how and to what extent the person can see, their physical, functional and health condition and how they learn. The basic problems in carrying out physical exercises of persons with visual impairments are related to adaptation: teaching methods, exercise area, props and equipment. Blind children learn through audible and tactile information (Grbović & Jorgić, 2017). It is necessary to constantly describe movements in detail in order to clarify incomplete visual information and for them to associate successive tactile information (Lieberman et al., 2006).

The aim of the research is the effects of a six-month individual exercise program on the parameters of body composition, postural disorders and physical deformities of a blind child.

METHODS

Subjects

The sample of the respondents is a blind boy (A.T.), aged 10 years. The respondent lost his sight two years before the research, due to a tumour. Parents' consent has been duly obtained for this research.

Procedure

A sample of variables consisted of variables for assessing body composition, postural disorders and deformities of the blind boy. Assessment of body composition has been performed using "InBody 770" body composition analyzer. The following indicators have been used for data processing: body mass, skeletal muscle mass, body fat weight, body mass index, body fat percentage, body height, segmental analysis (of the left arm, right arm, trunk, left leg and right leg); intracellular fluid, extracellular fluid, basal metabolism, child's obesity rate and mineral bone content. Assessment of postural disorders and body deformities has been performed using the "Spinal Mouse" instrument (Post & Lefernik, 2004). The following indicators of postural disorders and body deformities have been used for data processing: the angle of the kyphotic curve, the angle of the lordotic curve, the angle of the scoliotic curve in the thoracic region and the angle of the scoliotic curve in the lumbar region.

The experimental treatment of the individual exercise program was carried out in the duration of six months, three times a week. The duration of one treatment lasted from 30 min to 1 h. In addition to the basic rules of training, the principles of overloading, continuity, individuality and progressiveness have been taken into account. In the first month the treatment lasted from 30 to 40 min, in the second month from 40 to 45 min, and from the third to the sixth month from 45 to 60 min. In the experimental treatment, exercises of flexibility as well as exercises of prevention of postural disorders and body deformities of flat feet and spine deformities were carried out. The exercise program done in pairs has also been included, implying physical and tactile guidance. It also covered the exercise program for strengthening the trunk.

Statistical analysis

The data obtained during the initial and final measurement are presented in tabular forms. In terms of the case study, statistical data processing is not carried out.

RESULTS

Table 1 shows the results of body height, body weight, skeletal muscle mass and body fat weight of body mass index and percentage of body weight at the initial and final measurement. Body height (139.30 cm vs. 143.90 cm), body weight (41.90 kg vs. 43.60 kg) and skeletal muscle mass (12.40 kg vs. 14.00 kg) were numerically increased at the final measurement compared to the initial, while the body weight values were numerically lower (16.90 kg vs. 15.90 kg). The results of obesity parameters: body mass index (21.60 kg/m^2 vs. 21.10 kg/m^2) and body fat percentage (40.40% vs. 36.50%), which were numerically lower at the final compared to the initial measurement.

Table 1: The results of body height, weight, mass of skeletal muscle and body fat, body mass index and percentage of body weight at the initial and final measurement.

Parameter	Initial Measurement	Final Measurement
Body height	139.30 cm	143.90 cm
Body mass	41.90 kg	43.60 kg
Skeletal muscle mass	12.40 kg	14.00 kg
Body fat weight	16.90 kg	15.90 kg
Body Mass Index	21.60 kg/m^2	21.10 kg/m^2
Body fat percentage	40.40 %	36.50 %

In the assessment of the body composition of the segmental tissue analysis (Table 2), in all body segments there was a numerical increase in value: left arm (0.96 kg vs. 1.09 kg), right arm (1.00 kg vs. 1.12 kg), left leg (3.25 kg vs. 3.55 kg), right leg (3.19 kg vs. 3.58 kg) and trunk (11.10 kg vs. 12.10 kg).

Table 2: The results of segmental tissue analysis at the initial and final measurement.

Parameter	Initial Measurement	Final Measurement	Normal values
Left arm	0.96 kg	1.09 kg	0.95 - 1.29 kg
Right arm	1.00 kg	1.12 kg	0.95 - 1.29 kg
Left leg	3.25 kg	3.55 kg	3.78 - 4.62 kg
Right leg	3.19 kg	3.58 kg	3.78 - 4.62 kg
Trunk	11.1 kg	12.1 kg	11.10 – 13.50 kg

The analyses of other parameters include analyses of intracellular and extracellular fluids, basal metabolism, childhood obesity rate and content of minerals in bones (Table 3). The indicators of obesity rates were numerically reduced between the two tests (131% vs 126%), while intracellular fluid values (11.00 l vs. 12.30 l), extracellular fluid (7.30 l vs. 7.90 l), basal metabolism (909 kcal vs. 968 kcal) and bone mineral content (1.58 kg vs. 1.80 kg) were numericaly increased.

Table 3: The results of body mass index and percentage of body weight at the initial and final measurement.

Parameter	Initial Measurement	Final Measurement	Normal values
Intracellular fluid	11.00 l	12.30 l	12.20 - 15.00
Extracellular fluid	7.30 l	7.90 l	7.50 - 9.10
Basal metabolism	909 kcal	968 kcal	1261
Childhood obesity rate	131 %	125 %	90 – 110
Bone mineral content	1.58 kg	1.80 kg	1.50 - 1.84

The results of the analytical analysis of the spinal column at the sagittal level (Table 4) show a numerical increase at the final measurement compared to the initial (kyphosis 28° vs 33°; lordosis 19° vs. 30°). The results of the analysis of the spinal column at the frontal plane (Table 4) show a numerical decrease at the final measurement compared to the initial (thoracic scoliosis 3° vs. 2°; lumbar scoliosis 5° vs. 1°).

Table 4: The results of the analysis of the spinal column in the sagittal and frontal plane at the initial and final measurement

Parameter	Initial Measurement	Final Measurement	Normal values
Kyphosis	28°	33°	35° - 47°
Lordosis	19°	30°	20° - 36°
Thoracic scoliosis	3° (right)	2° (right)	0, (0 - 5)
Lumbar scoliosis	5° (left)	1° (left)	0, (0 - 5)

DISCUSSION

Based on the results from the initial and final measurement of the body composition, it can be perceived that positive changes have been located in the domain of the body composition. The body weight of the respondent at the initial measurement was significantly above the normal, while it was reduced at the final measurement. The body mass itself was reduced, but the good effect of the exercise program is even more reflected in correcting muscle-fat ratio (Ness et al., 2007). Namely, the exercise program achieved the final measurement results to be within the limits of normal values, compared to the initial measurement of the skeletal muscle mass when the result was below the normal. The body fat weight was extremely large at the first measurement, but it was reduced at the final measurement. However, it was not reduced within normal values due to the extremely high value at initial measurement (McCarthy, et al 2014). In the period between two measurements, the respondent increased his body height by 4.6 cm, which represents an excellent value of the parameter of growth and development. The obesity parameters at the initial measurement were extremely poor. Values and indexes of body weight and fat percentage in the body were very high. The exercise program managed to reduce them, but still not within the normal range, which is consistent with similar studies in the past (Wohlfahrt-Veje et al., 2014), in which physical activity in visually impaired people, involving various skills of movement, leads to improvement of shape and motor skills.

Segmental tissue analysis showed, at the first measurement, that the respondent was considerably deficient in lower extremity values, while the upper extremity and trunk values were also reduced or at the very limit compared to normal values. The exercise program has led to the final measurement results to be much more successful. The result of the segmental analysis of the upper extremities and trunk was perfect, while the lower extremities were close to the normal values along with an enormous progress over the initial measurement results. (Ohta et al., 2016).

At the initial measurement, the obtained results for the parameters of intracellular and extracellular fluids and content of minerals in bones were below the level of normal values. The obesity rate was significantly higher than the normal. The exercise program has given good results in terms of all parameters. Not only were all the parameters after the exercise program within the normal range, but there was also an acceleration of basal metabolism, which proves that the program had a positive effect on almost the entire body composition of the respondent (Saint-Maurice et al., 2016).

The results of the spinal column analysis show that, at the initial sagittal plate measurement, the respondent was diagnosed with kyphosis of 28° (normal values range from 35° to 47°) and a lordosis of 19° (normal values range from 20° to 36°), indicating insufficient physiological curvature of the spinal column and appearance of the "flat back" syndrome. The lack of proper physiological curves shows the muscle weakness and danger of the respondent to the extensive load of spine. At the final measurement, as the effect of a six-month treatment, the results showed that the kyphotic curve was 33°, which represents a progress and a great approximation to normal values. On the other hand, the result for the lordotic curve showed even greater success of the exercise program, since it was 30° and classified to the normal values of the physiological curve (Łubkowska et al., 2015).

At the initial frontal plane measurement in the thoracic part, there was a right scoliosis of 3°diagnosed, and in the lumbar region there was a left scoliosis of 5° which meant a danger of the curve progression in the frontal plane and serious body deformities. In the six-month exercise program, the spinal column curves in the frontal plane reduced so that the right thoracic scoliosis at the final measurement was 2°, and the left lumbar only 1°. This program was different from the traditional therapeutic procedure for preventing the progression of idiopathic scoliosis (Mordecai & Dabke, 2012), but it was a success. This fact gains importance, since it is a well-known fact that visual impairment is highly correlated with the rate of idiopathic scoliosis (Catanzariti et al., 2001). The sedentary lifestyle significantly negatively affects the body posture and favours the creation of postural disorders and physical deformities (Laštro et al., 2015), so that any program of systematic exercise of persons with visual impairment is better than hypokinesia (Paravlić et al., 2015).

CONCLUSION

Therefore, it can be concluded that the effects of the six-month individual blind child's exercise program on body composition, postural disorders and body deformities, are positive. The significance of this research is reflected in the fact that it exemplifies beneficial effects of the adaptive individual program of physical exercises of a blind child on the correction of body composition, postural disorders and physical deformities, and above all, the preservation of health, better socialization and improvement of life quality.

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THE EFFECTS OF FOLK DANCE ON THE CHANGES IN COORDINATION PARAMETERS IN STUDENTS AMATEUR DANCERS

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SUMMARY

The aim of this research was to establish the effects of the folk dance program – folklore – on the changes in the coordination abilities of students. The sample of respondents consisted of 44 respondentsdivided into two groups – dancers and non-dancers. The experimental group of 23 respondentsconsisted of the dancers of the Academic Folklore Ensemble "Oro" of the Students' Cultural Center from Niš and the Cultural Artistic Society "Kostolac" from Kostolac (18-25 years old), while the control group of non-dancers consisted of 21 respondents(18-19 years old). Five tests were used to estimate coordination abilities: sidesteps (leg coordination), 20 step-outs with bat intertwining(arms and legs coordination), skipping the horizontal jump rope (body coordination), turns in six squares(beat coordination) and tapping feet and fingers(arms and legs coordination).

A three-month folk dance program was implemented. The respondentspracticed for 120 minutes three times a week and the training consisted of three parts. The program consisted of the dances from Central and Southeastern Serbia. The t-test was used to determine the difference between the initial and the final measurement, and MANCOVA and ANCOVA were used to determine the effects of the implemented experimental program. The level of statistical significance was .05. All of the data was processed in Statistica 7.0 statistical package for data processing. The results of the research have shown that the applied dance program has significantly influenced the improvement in coordination in the experimental group, while individually, the variable for assessing leg coordination has given the greatest contribution. The authors conclude that the folk dance in the practical sense significantly influences the improvement in leg coordination.

Key words: coordination, dancers, non-dancers, folklore, effects.

INTRODUCTION

In the modern world, a trend towards the reduction of physical activity can be noticed. Nowadays, the level of physical activity has decreased, and even 2/3 of the population are not as physically active as it is necessary (Reed, 2007; Fogelholm, Stallknecht&VanBaak, 2006; Carrol &Dudfield, 2004; Trost, Owen, Bauman, Sallis& Brown, 2002). The trend of decreasing the level of physical activity has been noticed in all population groups, and research shows that a decrease in the level of physical activity has also been noticed in the student population (Vuillemin et al., 2005., DeVahl et al., 2005., Fogelholm et al., 2006). The sedentary way of life has become dominant among students (Gošnik, Bunjevac, Sedar, Prot&Bosnar, 2002).

A large number of exercise programs allow the application of exercise in different population groups regardless of gender, years of age, current psychophysical abilities, etc. Dance as a form of physical activity is largely present as a form of exercise in student population, regardless of it being a standard, Latin-American, folk, or contemporary form of dance. Folk dance is a form of art that lives in the people, and it shows the relationship towards life, nature, work, and feelings. It is passed down from generation to generation, but it also changes with time. As a whole, folk dance and folk song are parts of folk creativity, i.e. folklore. It is characterized, among everything else, by anonymity, since the creators are usually unknown. These folk works of art were not created for personal affirmation, but in the interest of community. Speech, song, music, and dance connected by rhythm made the creation of folk dance possible (Kostić and Uzunović, 2013). Different dance programs can influence a great number of anthropological characteristics and abilities. The effects of different dance programs on motor abilities have been proven (Bennet, 1956, afterOreb, 1984; Lavoie andLebe-Neron, 1982; Kostić, 1997; Karanov, 2005; Uzunović, 2008).

During the realization of folk dances, a great number of factors influencethe performance of movements: the strength of arms and the shoulder region, leg strength, core strength, the flexibility of the belt, leg coordination (Oreb1984; Bennet 1956; Jocić,UzunovićandKostić 2004). Also, coordination as a complex motor skill has an important role in solving certain motor tasks during the dance performance (Oreb, 1984; Uzunović, 2004, 2008, 2009; Jocić, Uzunovićand Kostić, 2004; Uzunović, Kostić, Zagorc, Oreb, Jocić 2005; Kostić, Uzunović, Zagorc, OrebandJocić, 2006; Uzunović, KostićandMiletić, 2009; Kocić, KaranovandŠolaja, 2014).The term ‘coordination’ is understood as a complex motor ability of a fast, efficient and precise motor response in stressful situations, and there is a great number of definitions of the term in practice. Coordination represents the ability to fulfill the assigned movements that require the cooperation of body parts without mental tension or errors with minimal effort (Drabik, 1996).Coordination could be most easily described as the ability to perform simple and complex movements, i.e. the ability to perform complex movements, but also to quickly learn new movements and more quickly exchange one movement with another (Drabik, 1996).

The aim of this research was to determine the effects of a three-month dance program of folk dance – folklore – to the parameters of coordination in students, amateur dancers.

METHODS

For the needs of this research, appropriate procedures that corresponded to the set aim of the researchwere applied.

Subjects

The sample of respondents

The sample of respondents consisted of a total of 44 students aged 18 to 25, divided into two subsamples. The first subsample consisted of 23 respondents, amateur dancers of folk dance, who made up the experimental group. This subsample was made up of the members of two dance ensembles: ACAS “Oro” from Niš and CAS “Kostolac” from Kostolac. The second subsample was made up of 21 students who were not involved in any organized form of physical activity, and the respondents of this group did not take part in any kind of dance before.

Procedure

The sample of measuring instruments

The following tests were applied to determine coordination:

- ***Sidesteps (leg coordination)(Metikošet al., 1989);***
- ***20 step-outs with bat intertwining (arm and leg coordination)(Kurelićet al., 1975);***
- Skipping the horizontal jump rope (body coordination); (Marčelja et al., 1973);
- Turns in six squares(beat coordination)(Kostić, 1995)and
- Tapping feet and fingers(arms and legscoordination); (Hošeket al., 1973).

Experimental exercise program

The respondents practiced three times a week, and for the statistical processing only those who had 80% training attendance during the period of examination were taken. The respondents danced following the program of folk dance from Central and Southeastern Serbia. The training structure is shown in table 1.

Table 1 *- Program structure*

	Content	Frequency	Time in min. per week
Introductory (30 min)	- The techniques of the basic steps of the folk dances of Serbia - Warm-up exercises, natural forms of movementand body shaping exercises	3x	
Main (80 min)	- Practicing the choreographies of the folk dances of Serbia		
Final (10 min)	- Breathing and relaxation exercises - Activity analysis - Stretching exercises		
Total (120 min)		3x per week	360 min

Statistical analysis

Data Processing

The basic parameters of descriptive statistics were calculatedfor each group (mean values, standard deviations, minimum and maximum values, range). Within the comparative statistics, the t-test was applied, and for determining the effects of the dance program, analysis of covariance was used (ANCOVA and MANCOVA). The statistical significance level was .05, and the Partial Eta coefficient was also calculated.The results were processed using the Statistica 7.0 statistical package for data processing (StatSoft.Inc., Tulsa, OK, USA).

RESULTS

The results of the research are shown usingtabular display. The values of the basic descriptive parameters of the EXP and CON group respondents in the initial and final measurement are shown in table 2.

The results obtained indicate that a normal distribution of results is present, and that the respondents of the control group showed better results at the final measurement than initially.

Table 2 - Basic parameters of descriptive statistics forthe experimental (n = 23) and control (n = 21) groupat the initial and the final measurement

DANCERS n=23	INITIALmeasurement					FINALmeasurement				
	Mean	Std.D.	Min	Max	Rang	Mean	Std.D.	Min	Max	Rang
Sidesteps	10,20	1,37	7,86	13,05	5,19	9,05	1,05	7,76	12,00	4,24
20 step-outs with bat intertwining	23,69	6,25	11,00	36,90	25,90	20,33	5,66	12,00	32,37	20,37
Skipping the horizontal jump rope	14,26	7,79	0,00	29,00	29,00	18,00	8,13	1,00	35,00	34,00
Turns in six squares	4,70	1,18	3,00	7,00	4,00	4,83	1,27	3,00	7,00	4,00
Tapping feet and fingers	13,35	3,46	6,00	21,00	15,00	13,04	3,51	5,00	20,00	15,00
NON-DANCERS n=21	Mean	Std.D.	Min	Max	Rang	Mean	Std.D.	Min	Max	Rang
Sidesteps	10,19	1,27	9,00	15,10	6,10	10,09	1,32	8,61	15,00	6,39
20 step-outs with bat intertwining	17,13	3,49	12,00	24,00	12,00	16,48	2,81	13,00	23,00	10,00
Skipping the horizontal jump rope	20,43	5,98	6,00	27,00	21,00	21,48	7,16	7,00	31,00	24,00
Turns in six squares	3,23	1,09	2,00	6,00	4,00	3,38	1,02	1,00	5,00	4,00
Tapping feet and fingers	14,90	2,57	10,00	20,00	10,00	15,48	2,48	10,00	19,00	9,00

Legend: (Mean) – arithmetic mean; (Std.D.) – standard deviation; (Range) – range; (Min) – minimal value, (Max) – maximal value

In Table 3, the differences between the initial and final measurements in the parameters of the coordination of the experimental and control group are shown. On the basis of the results obtained using the t-test, it can be concluded that only the subjects of the experimental group had statistically significant changes between the two measurements.It can be noticed that after the applied three-month folk dance program, the leg coordination of the dancers has improved.

Table 3 - The differences between the initial and the final measurement

	EXPERIMENTAL				CONTROL			
	INITIAL	FINAL	t	p	INITIAL	FINAL	t	p
Sidesteps	10,20	9,05	3,19	**.003**	10,19	10,09	0,23	.813
20 step-outs with bat intertwining	23,69	20,33	1,91	.063	17,13	16,48	0,65	.514
Skipping the horizontal jump rope	14,26	18,00	-1,59	.118	20,43	21,48	-0,51	.610
Turns in six squares	4,70	4,83	-0,36	.720	3,23	3,38	-0,43	.664
Tapping feet and fingers	13,35	13,04	0,30	.768	14,90	15,48	-0,73	.468

To determine the effects of the implemented activities, a multivariate analysis of covariance variables was used to estimate the coordination between dancers and non-dancersat the final measurement, with the neutralization of the differences in the coordination abilities at the initial measurement.

Table 4 shows a multivariate analysis of the covariance of applied variables for assessing the coordination between the experimental group (dancers) and control group (non-dancers) at the final measurement, with the neutralization of the differences in the coordination abilities at the initial measurement.

Table 4 - Multivariate covariance analysis MANCOVA

Wilks	F	df1	df2	p	Partial eta-squared
0,69	2,83	5	39	**.031***	0.301

Legend: Wilk's Lambda– Wilk's Lambda Test, F –F approximation, df – degrees of freedom, p– level of significance, statistical significance of differences *< .05<Partial Eta Squared –level of impact.

It can be concluded that there is a statistically significant difference at the multivariate level between dancers and non-dancers, at the significance level of .05 (Sig. = .031).By examining the Partial Eta Squared coefficient, a high level of impactof the treatment can be noticed (according to Cohen, high impact values are greater than 0.138 or 13.8%) on the differences between groups at the final measurement. More specifically, this means that the difference between the groups and hence the applied treatments, explainsthe 30.1% of the variance in the results of the final measurement of motor abilities.

Table 5 shows the results of a univariate covariance analysis (ANCOVA), with corrected arithmetic means.

Table 5 - Univariate analysis of covariance

	Group	Adj.Mean	F	p	Partial eta-squared
Sidesteps	EXP	8,99	12,94	**.001**	0.568
	CON	10,55			
20 step-outs with bat intertwining	EXP	17,73	0,56	.456	0.253
	CON	19,07			
Skipping the horizontal jump rope	EXP	21,29	1,15	.288	0.459
	CON	18,17			
Turns in six squares	EXP	3,70	0,23	.631	0.453
	CON	3,45			
Tapping feet and fingers	EXP	14,09	0,06	.798	0.096
	CON	14,42			

Legend: Adj. Mean – corrected arithmetic mean, EXP – experimental group, CON – control group, F – Ftest, p– level of significance, statistical significance of differences ** <.01i *< 0.05, Partial Eta Squared – level of impact (low*, moderate**, high***)

Based on the obtained results of the conducted statistical procedure, it can be concluded that statistically significant effect exists only in the assessment test of leg coordination, on the Sidesteps test (r = .001). By analyzing other results, it is evident that there is a numerical difference in the corrected arithmetic means between the groups tested in favor of the experimental group, except for the test of Tapping feet and fingers, where a slightly better result was achieved by the control group.

DISCUSSION

A three-month dance research program was implemented in order to determine changes in the parameters of coordination on a sample of students. The relationship between dance activities and coordination skills was also confirmed by the results of Oreb (1984), where, on the basis of the results obtained, it was established that different sports have different impact on motor skills.While in the Vardar zone, repetitive strength and endurance stand out, in Morava zone (which is the content of this program), coordination and speed stand out.

If we would individually compare the obtained results of the initial and final measurement (t - test) on the sample of dancers of folk dance, we would see that in most tests no significant statistical difference was noticed, except for the Sidesteps test; however, numerical differences can be noticed. It can be said that the implemented three-month program had a positive influence on leg coordination.Similar results were obtained in other studies(Uzunović, 2008, 2009; Uzunović, Kostić andMiletić, 2009; Kostić, Uzunović, Oreb, Zagorc andJocić, 2006; Uzunović, Kostić, Zagorc, Oreb andJocić, 2005).

When it comes to the control group, there are no statistically significant differences between the initial and final measurements with regard to the results obtained, unlike the study carried out by Uzunović (2009), where the experimental and control group had a positive transformation of coordination abilities in the investigated period.

The results of multivariate analysis of covariance showed that there are statistically significant effects on the sample of dancers.The obtained results are in favor of the experimental group, since it is evident that the dancers showed significant transformations in the abilities examined. The three-month period during which the transformation process was monitored under the influence of folk dancewas sufficient for the effect to be achieved only in leg coordination (ANCOVA).The result is logical since the dance program of folk dance mainly consists of movements and elements of the leg technique.This confirms that it is possible to influence the transformation of some parameters of coordinationin three months, as Uzunović proved in his research (2008, 2009).

CONCLUSION

The decrease in movement and thus the trend of decreasing the level of physical activity is observed in all population groups, and research shows that a decrease in the level of physical activity is also observed in the student population.The sedentary lifestyle has become dominant among students.The results obtained from the conducted research will contribute to the scientific knowledge about the influence of dance activities on the development of coordination abilities of students amateur dancers.Folk dance has, in the practical sense, pointed to a significant improvement in leg coordination.Although in other tests no statistically significant effects were found, it can be concluded that the implementeddance program of folk dance - folklore – has contributed to the overall development of coordination. By introducing more diverse exercises and dance structures during the warm-up and realization of the main part of the lesson, it is expected that all the parameters of coordination would be improved, which would contribute to the quality of the performance of folkdance.

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FLAT FOOT IN PRESCHOOL CHILDREN: A SYSTEMATIC REVIEW

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SUMMARY

Flat foot is one of the most common bodily deforimities that is located on the locomotor apparatus, which appears as an increasingly frequent occurence in children, and also in adults. It is therefore extremely important monitor the morphological trend of changes in the bone, joint, ligament and muscle apparatus of the foot from earliest age. Because if it is not detected in time that there is a certain deviation from the normal state, there may be more complex changes to the foot (structural nature). The aim of this paper ist to show the frequency of flat foot deformities (pes planus) in preschoool children. The research covered seven paper published in period from 2010. to the present. The descriptive method and theoretical analysis was used to collect, classify, and analyze the targeted research. As for the methodological approach in indentifying scientific papers that were based on this topic, scientific sites such as: Kobson, Pubmed and Google scholar have been used. The results showed that most research supports the initiative and theory that preschool period is the most suitable period for the development of certain changes in the morpho-anatomical foot model in children. Studies also suggest that particular care should be taken in this period of the child and act preventively in order to prevent progression of foot disorders to a higher stage of disorder (structural change).

Keywords: flat foot, disorder, preschool age, child, morphological trend.

INTRODUCTION

The preschool period of the child's development includes a period from 4-7 years. It is especially important because certain sports branches in this period start with selection (swimming, sports and rhythmic-sports gymnastics), so that the interest of trainers for this development period is significant (Mladenović-Ćirić, 2008). It is also a very sensitive period, for one simple reason: that is the stage of growth and development, its distribution is progressing and any disruption of it could lead to the creation of a danger of the emergence of certain unnatural disturbances that would greatly undermine the distribution. If this is a period suitable for the development of children's motor skills, then we must approach it very carefully, taking into account all the biological and anatomical characteristics of the child, without disturbing its natural progression. Motor skills and their structure are very complex, and the best method for developing these basic skills that is suitable for this childhood age is the game. Spontaneous physical activity is up to school when enrolled with school age. It can be noted that children play less and exercise physical activities in the form of sports games, and spend most of their time in a passive position, sitting or lying (Simov, Minić & Stojanović., 2011). What is certain is that insufficient movement activity leads to other chronic diseases as well as to patho-physiological and patho-anatomic changes that can certainly be detected in the spinal column (kyphosis, lordosis, scoliosis, kifolordosis, etc.) and in deformation on the locomotor apparatus (H-legs, O-legs, gene recurvatorum, saber knee, flat feet). Flat foot is one of the most common bodily deformities that is located on the locomotor apparatus.It is extremely important to follow the morphological trend of changes in the bone, ligament and muscular apparatus from the earliest days, from preschool age, because if we do not detect the time period for a certain deviation from the normality of muscular distribution, structural (fixed) deformities can occur.

The foot, as well as the spinal column, is the phylogenetic youngest part of the locomotor apparatus, which has not adapted to the new conditions of life today, and therefore, in these segments, postural disorders and body deformities, varying degrees, occur in the largest percentage (Živković, 2009). The aim of this review paper is to present works that were based on anatomical and kinesiological analysis of the foot, as well as the frequency of flat feet in preschool children, as well as the influence of various factors on the symptomatic appearance of this deformity.

METHOD OF RESEARCH

As for the methodological approach in detecting and identifying scientific papers that were based, or at least approximately based on this topic, scientific sites such as: Google scholar, Kobson, Pubmed were used.. In order to facilitate the methodological approach for looking for scientific papers related to the topic, the following terms were used in order to facilitate the search in the corpus of scientific knowledge: in the translation the key words are: flatfoot, deformity, preschool, children. The descriptive method and theoretical analysis was used to collect, classify, and analyse the targeted research Periodization that will certainly be taken into the analysis to detect the level of correlation in flat foot in children is the period from 2010. to the present, so as to determine if it's progress is more or less to determine an adequate corrective methodology in the prevention and correction of it's promotion.

THEORETICAL REVIEW OF PROBLEMS

Seven papers are presented in total, chronologically in Table. Each survey is presented according to the following parameters: reference-first author and year of publication of papers, purpose of research, sample of respondents and results of research. By inspecting this table, it can be concluded that the works are heterogeneous, both by methodological research and by the number of respondents, age, as well as in terms of gender differences. However, all papers were aimed at researching the insufficient foot model of pre-school children. The largest number of respondents can be detected in work (Simov, Minić and Stojanović, 2011), while the smallest number of respondents were detected in work (Bjeković, Arnaut and Gardijan, 2011). Further, by analyzing this table, it is possible to establish that there is a certain degree of variability in terms of chronological statistics. The oldest sample of respondents can be detected in work (Abolarin et al., 2011), while the youngest sample of respondents in work (Szymanka et al., 2015). Also, a certain degree of gender-based variability can be noticed, where most of the papers had respondents of both sexes (Mickle et al., 2011; Bjeković et al., 2011; Kun-Chung Chen et al., 2012;). In one study, the sample of female respondents was female (Simov et al., 2011;).

Reference	The aim of the research	Sample	Results
1. Mihajlović, Smajić & Sente (2010)	The aim of this study was to establish the relationship of the appearance of deformity of the foot with the age-old characteristics of the girls.	The sample of respondents consisted of 272 girls aged 4-7-years.	On the basis of the obtained results, it was found that in the girls of the older age, the pes cavus is the most pronounced.
2. Simov, Minić & Stojanović (2011)	The aim of their research was to determine the frequency of physical deformities in children aged 6-7 years.	The sample of respondents was only 968 children in the school year 2010/2011. year.	On the basis of the obtained results, the authors came to the conclusion that the biggest flourishing of children with a lowered vault of feet I to IV (30,78).
3.Bjeković, Arnaut & Gardijan (2011)	The aim of this study was to determine the presence, shape and degree of deformity of the feet in pre-school children.	The sample of respondents were pre-school children. A total of 66 respondents were divided into two sub-girls (32) and boys (34).	On the basis of the obtained results, it was found out that there is a high coefficient of deformation of the longitudinal and lateral part of the foot.

4. Abolarin, Aiyegbusi, Tella & Akinbo (2011)	The aim of this study was to determine the effect of age on the age and the level of footwear (sneakers) as a predictor variable on the symptomatic appearance of flat feet.	The sample of respondents consisted of 560 children aged between 6 and 12 who were divided into two groups	On the basis of the results obtained, the authors came to the conclusion that the age of the age as the prediction has the greatest impact, and that the level of shoes (sneakers) in this study does not influence.
5. Mickle, Steel & Munro (2011)	The aim of this study was to determine whether the structure of the foot can depend on sex in pre-school children.	The sample of respondents consisted of 52 girls and 36 boys between 3 and 5 years of age.	On the basis of the obtained results, the boys showed a significant coefficient of the incidence of flat foott in relation to girls. They did not find a difference in the foot structure of both sexes, although the boys had a much thicker layer of upper leg.
6. Kun-Chung Chen & Li-Chen Tung & Chih-Jung Yeh & Jeng-Feng Yang & Jing-Fu Kuo & Chun-Hou Wang (2012)	The aim of the study was to examine the changes that can be the main predictors for the formation of flat feet in pre-school children in a one-year follow-up study.	The sample of respondents was 580 children of pre-school age (boys = 297), (girls = 283) from 3 to 5 years of age.	A one-year study has shown that some children with pre-school age with flat feet can influence the normalization of their condition, while children with normal feet can experience the initial symptoms of this defect.
7. Szymanska & Mikolajczyk (2015)	The aim of the study was to determine whether the overweight of the body in pre-school children is moving towards the formation of a flat foot.	The sample of respondents consisted of 207 children who participated in a 24-month study. The age of the respondents ranged from 3.5 to 4.4 years.	They found that between 4-6 years, the body weight increase in body weight in obese boys and girls adversely affects the medial and longitudinal arch of the foot that has a tendency to relax

DISCUSSION

Mihajlović, Smajić & Senta (2010) have done research to determine the frequency of deformity of the foot in children 6-7 years of age. They assumed that the intense formation of the foot arch ends by the age of 4, that the sample be aged from 4 to 7 years of age. What is justified, taking into account that this is a period that is very suitable for the initial stage of the development of a flat foot, which is previously detected by some irregularity, time will be on the side of the experts in prevention and correction from the possibility of creation and progression to a more advanced level of condition. They came to conclusion that the pes transversoplanus calcaneo valgi occurs in the girls preschool population. Also, they came to the data, that with the increase in the age of girls, the number of these deformities are decreasing. They believe that the reason for this lies in the fact that the period of formation of the foot arch is still ongoing. Based on the research, they came to the conclusion that there is a connection of a flat foot with age and consider that the older the child, the lower the occurrence of deformities. Simov, Minić & Stojanović (2011) conducted a research in order to determine the frequency of deformity in children aged 6-7 years. They found that there was a high coefficient of lowered foot arch in children, which they explain as a consequence of a decrease in the muscle tone, the tibia and muscles of the lower leg. The highest percentage is the lower arch of the foot of the first degree, then the second, and the smallest percentage of the third and fourth. The results indicate that 17.6% of the first lower arch of the foot, 8.37% of the secon, and 3.92% of the third, and 0.83% of the fourth. Of the total number of children surveyed 30,78% have a lower arch of the foot. It is necessary to note that physical activity is significantly reduced in today's (urban) conditions, a small number of children can now see how they exercise natural forms of movement in natural conditions, which certainly makes a certain contribution to these statistical data on the frequency of flat-foot deformities. Bjeković, Arnaut & Gardijan (2011) found that 74.24% of deformities of the foot are present in the investigated cause. Only 17 children out of a total of 66, as it has been examined, do not have any deformity of the foot in any form. Foot deformities in this study are more common in girls compared to boys. Particularly pronounced deformities are pedes-plani-lowered foot, pedis valgi- inverted foot and pedis recti-twisted foot. In boys, deformity is expressed in relation to girls pedes planovalgi-twisted foot. The obtained results of the study indicate a relatively high percentage of deformities of the longitudinal and transverse arch of the foot. In their research, Abolarin, Aiyegbusi, Tella & Akinbo (2011) examined how and in what way the predictive role has age, as well as different types of footwear (shoes) on the incidence of physical deformities such as the flat foot. Their results show that footwear types and age as predictive variables have had an impact on flat-foot prevalence among children living in urban and rural areas, but they also found that the type of footwear is not a factor for the development of flat feet. In this study, the prevalence of a flat foot is significantly under the influence of age. The highest percentage of flat foot was found in children aged 6 years, more than half of children in urban areas (51.2%), and in rural children around 35% are affected by this deformity. Not surprisingly, children in the urban environment are becoming less physically active. Passive transports (car, bus) are used instead of stimulating the motor control of the locomotor system on the natural biological system. They have come to the conclusion that premature wearing overweight obesity can be associated with age are factors that influence the prevalence of a flat foot in children. Kun-Chung Chen & Li-Chen Tung & Chih-Jung Yeh & Jeng-Feng Yang & Jing-Fu Kuo & Chun-Hou Wang (2012) have been working to investigate changes as well as examine changes as well as the signs of a flat foot. Their research showed that the prevalence of flat foot in pre-school children who participated in this study decreased its coefficient of 68.2% in three-year-old children to 37.8% in five-year-old children, as well as the Chippaux-Smirak CSI index> 62.70 % decreasing with increasing age, from 66.3% in three-year-old children to 58.7% in five-year-olds. The authors explain this as a prevalence of a flat foot decreases during growth, and that the progress of development of the foot arch is faster for young children.

This only suggests as well as confirms the assertion by many researchers that the timely detection of certain symptomatic signs that can be the basis for pathological progression and the creation of certain discomforts in this case a flat foot leads to stabilization, or to stop its progression. Szymanska & Mikolajczyk (2015) have done research in order to determine whether overweight in preschool children has a negative effect on the very anatomical-morphological structure of the foot. In this study, it was found that the longitudinal arch of the foot at the left and right legs in the boys was significantly lower than in the girls, and this tendency did not change during the duration of the 24-month research methodology. They have come to the conclusion that excessive obesity negatively affects the longitudinal arch of the foot in pre-school children. Mickle, Steel & Munro (2011) have been working to investigate whether the movement of the foot, as a daily locomotor activity in preschool children correlates with the objective time spent in physical activity and with sedentary behavior. The analysis of the determination of the mechanical pressure generated by walking is significantly related to the level of physical activity in preschool children, where preschool children who have generated a high coefficient of pressure across the whole foot and heel are classified into that group of subjects that are less concerned with physical activity, as opposed to children who achieved a lower pressure coefficient on the platform. While girls who achieved a high pressure coefficient under the fingers of the foot belong to the group sedentary live mode this, than girls who have achieved a lower pressure coefficient on the platform. Generally speaking, most papers supported the initiative and the theory that pre-school period is the most suitable period of the beginning of the disruption of the morpho-anatomic structure of the foot in children. The elasticity, and the very plasticity of the ligament bonds, joint structures, tendons and muscles of the foot is very sensitive and accompanied by morphological changes, which certainly occur in this period of the child. Most authors consider the study of the age of the respondents, sex, as well as age, that there is a gender effect as well as years of age with an increase in the prevalence of the flat foot, as well as the difference in the appearance of flat-foot disorders between the sexes. Some have found that, as the child is older, the incidence of flat spine disorders is lower. All these are in some ways potential variables that can certainly give a certain (percent) contribution to the morpho-anatomical change in the foot. Some research also pointed to the importance of physical activity in the form of applying natural forms of movement and exercise in maintaining normal anatomical foot image. However, taking into account the modern way of life, it can be noted that there has been a statistical decline in the use of natural forms of movement, which, in addition to the occurrence of post-mortem changes, also leads to a change in terms of deterioration of body status (obesity). Research by individual researchers also found that variables such as reduced movement, use of means of transport, excessive obesity and inappropriate footwear (sneakers) can significantly contribute to the disruption of the biomechanical model of the locomotor apparatus, in this case the biomechanical foot model. However, what has not been investigated is the effect of genetics on the transformational morpho-anatomic process of the anatomical parameters of the foot in terms of disrupting the model itself. Summarizing research, it is evident that special attention should be paid to this period of the child and to act preventively in order to prevent progression of foot disorders to a higher stage (structural nature). Also, it is necessary to pay attention to the transition from pre-school to school period and the influence of the school period on the transformational-morpho-anatomical process of the very architecture of the foot.

CONCLUSION

Flat foot is one of the most common physical deformities that affects the vast majority of the population. The latest research has shown that a flat foot represents a global problem not only in society, but also in the world together with other body deformities and other forms of deformation of the body (excessive obesity). Therefore, in the early childhood, a system of prevention must be provided, both in kindergarten, in school, and in the family.

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THE POSTURAL STATUS OF FEMALE FIRST LEAGUE BASKETBALL PLAYERS

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SUMMARY

The aim of this research was to determine the postural status of first league female basketball players. The sample of participants consisted of 12 elite senior basketball players who had been involved in a training program for more than eight years. To evaluate the postural status of the spinal column in the frontal and sagittal plane, as well as to evaluate the postural status of the legs and feet in the frontal plane, a special measuring instrument was used (Formetric 4D System, Diers, Germany). To determine the differences in the prevalence of deformities and normal posture, the Chi square test was used. The results indicated that the prevalence of physical deformities of the spinal column are found in the following percentages: kyphosis (66.7%), lordosis (100%) and scoliosis (91.7%) while the prevalence of the percentage of leg and arch deformity was: knock-knees (8,3%), bowlegs (91.7%) and flat feet (58.3%). Based on the obtained information on their postural status, we can conclude that frequent control and monitoring of postural status among elite female athletes is necessary. In addition, the constant strengthening of both sides of the body is needed, especially in the case of sports where the specific nature of the technical elements is tied to the dominant side of the body.

Key words: kyphosis, lordosis, scoliosis, knock-knees, bowlegs, flat feet, deformities, basketball, senior age group, women

INTRODUCTION

Postural status represents a particular position of body segments in static and dynamic positions (Demeši-Drljan, & Mikov, 2012). However, due to increasingly more demanding and dynamic sports competitions today physiological and postural parameters represent a great challenge for the athlete himself (Marelić, 2015) . In accordance with the specificities of each sport, or sport techniques, we could use one (the dominant) side of the body more intensely, that is, one group of muscles more compared to the other, which as a result leads to a muscle imbalance, or a parallel discrepancy in the increase in the power of the muscles of the dominant and non-dominant side of the body(Gioftsidou, Beneka, Malliou, Pafis & Godolias, 2006; Nešić, Ostojić, Đokić & Šeper, 2012). The muscle disbalance which occurs as a result of improving sport techniques which are not symmetrical leads to the occurrence of deformities in the postural status.

Deformities, based on the level of muscle disbalance, can be classified as deformities of the functional type and deformities of the structural type. Deformities of the functional type are those which occur as the result of insufficient muscle power or a great difference between the muscle power of the dominant and non-dominant part of the body, and the structural type represent changes which in addition to muscle tissue also affect both the ligaments and bone tissue. Postural disorders can be noted on the human body in two planes, the sagittal and frontal (Milenković, 2007). Deformities located on the spinal column in the sagittal plane are kyphosis, lordosis and flat back, while the deformity located in the frontal plane of the spinal column is known as scoliosis. Deformities which occur in the region of the legs in the frontal plane are knock-knees and bowlegs, while deformities of the foot are flat feet and hollow foot(Živković, 1998; Živković, 2009) .

Determining postural status is important for athletes of all ages, categories and levels of competition, especially for elite professionals, due to the exceptionally great physical exertions which they undertake with the aim of achieving higher competitive results, so that they could keep their state of health at a high level and to have a strong and healthy body following the end of their sports careers (Kilinç, Yaman & Atay, 2009; Baldini, Beraldi, Nota, Danelon, Ballanti & Longoni, 2012). Considering the fact that the disbalance in the prevalence of body activation when performing basketball techniques might cause inequality in the muscle power of the dominant and non-dominant side of the body, it is interesting to determine what the state of postural disorders among elite female basketball players is. In accordance with the previously determined facts, the aim of this paper is to determine the postural status of the senior female basketball players of the First league of Serbia.

METHODS

Participants

The research included 12 participants. The participants were all women, senior basketball players competing in the First league of Serbia, with an average age of 21,5 ± 5,7 yrs. The female participants had been involved in active training for more than eight years.

Procedure

To determine postural status in the frontal and sagittal plane of the spinal column, but also to determine the postural status of the legs in the frontal plane and determine the status of the feet, a particular measuring instrument was used (Formetric 4D System, Diers, Germany). "Diers" represents the most modern of instruments from the group of non-invasive measuring methods, that is, for the evaluation of the state of the postural status of the whole body in the frontal and sagittal plane, as well as in static and dynamic circumstances (Betsch, Wild, Jungbluth, Hakimi, Windolf, Haex, & Rapp, 2011; Mangone, Raimondi & Paoloni, 2013). The validity and reliability of the instrument (Formetric 4D System, Diers, Germany) was determined in various studies (Somoskeöy, Tunyogi-Csapó, Bogyó & Illés, 2012; Lason, Peeters, Vandenberghe, Byttebier & Comhaire, 2015). The instrument was also used among participants of various age groups (Sung, Yoon & Park, 2015; Knott, Sturm, Lonner, Cahill, Betsch, McCarthy, Kelly, Lenke & Betz, 2016). Based on the data on the postural status of the spinal column in the sagittal plane obtained during measurements using this instrument, the following variables were isolated: KIF I – kyphotic posture, first degree; KIF II – kyphotic posture, second degree; LOR I – lordotic posture, first degree; LOR II – lordotic posture, second degree; SKOL I – scoliotic posture of the first degree; Xn I – knock-knees, first degree; On I – bowlegs, first degree; RS I – flat feet, first degree; Rs II – flat feet, second degree.

Statistical analysis

The obtained measurements are represented as frequencies and percentages. To determine the differences in the prevalence of deformities and normal body posture among the female participants, we used the Chi square test.

RESULTS

Table 1. Descriptive parameters of the female basketball players, senior competitors in the First league of Serbia.

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
tvis	12	164.00	194.50	176.76	8.15
tmas	12	58.20	87.70	69.27	8.32
BMI	12	19.00	26.50	22.66	2.21
Valid N	12				
tvis – body height; tmas – body mass; BMI – body mass index					

Table 1 represents the basic parameters of descriptive statistics on the numeric ratio of the prevalence of the deformities as well as information on their body height (SD 176,7 ± 8,15), body mass (69,27 ± 8.32) and the body fat index (22,26 ± 2.21). These parameters were presented for a more complete description of the sample of participants.

Table 2. Postural status of the spinal column in the sagittal and frontal plane among female basketball players, senior competitors in the First league of Serbia.

Postural deformities in the sagittal plane of the spinal column						Postural deformities in the frontal plane of the spinal column		
Kyphosis			Lordosis			Scoliosis		
Variable	Frequency	Percent	Variable	Frequency	Percent	Variable	Frequency	Percent
N	4	33.3	N	0	0	N	1	8.3
KIF I	5	41.7	LOR I	3	25	SKOl I	11	91.7
KIF II	3	25	LOR II	9	75			
Total	12	100	Total	12	100	Total	12	100

N – number of participants without the deformity; KIF I – kyphosis, first degree; KIF II – kyphosis, second degree; LOR I – lordosis, first degree; LOR II – lordosis, second degree; SKOL I – scoliosis, first degree; Total – overall number of statistically processed participants within the variable.

Based on the results shown in Table 2, that is, the overview of the basic descriptive parameters of the numeric ratio of the prevalence of the deformity of the spinal column in the sagittal and frontal plane, among female basketball players, senior competitors of the First league of Serbia, the following results were obtained: kyphotic posture of the first degree was found in 8 of the participants (66.7%), lordotic posture in 12 of the participants (100%) and scoliotic posture in 11 of the participants (91.7%).

Table 3. Postural status of the legs in the frontal plane and flat feet among the female basketball players, senior competitors in the First league of Serbia.

Postural deformities of the legs located in the frontal plane						Postural status of the feet		
Knock-knees			Bowlegs			Flat feet		
Variable	Frequency	Percent	Variable	Frequency	Percent	Variable	Frequency	Percent
N	11	91.7	N	1	8.3	N	5	41.7
Xn I	1	8.3	On I	11	91.7	RS I	4	33.3
						RS II	3	25
Total	12	100	Total	12	100	Total	12	100

N – the number of participants without a deformity; Xn I – knock-knees, first degree; On I – bowlegs, first degree; RS I – flat feet, first degree; Rs II – flat feet, second degree; Total – overall number of statistically processed participants within the variable.

Based on the results shown in Table 3, that is, the overview of the basic descriptive statistics parameters of the numeric ratio of the prevalence of leg deformities in the frontal plane, as well as the prevalence of flat feet among the female basketball players, senior competitors in the First league of Serbia, the following results were obtained: knock-knees were noted in one of the participants (8,3%), bowlegs in 11 (91.7%) and flat feet in 7 of the participants (58.3%).

Table 4. The results of the Chi square test for the female basketball players, senor competitors in the First league of Serbia.

Test Statistics					
	Kyphosis	Scoliosis	Knock-knees	Bowlegs	Flat feet
Chi-Square	1.333[a]	8.333[a]	8.333[a]	8.333[a]	.333[a]
df	1	1	1	1	1
Asymp. Sig.	.248	.004	.004	.004	.564

The results in Table 4 represent the results of the Chi square test of the female basketball players, senior competitors of the First league of Serbia. Based on the obtained results we can note a statistically significant difference between the female basketball players with and without a diagnosed deformity for the following variables: Scoliosis (p=0.004), knock-knees (p=0.004), and bowlegs (p=0.004), while for the variables: Kyphosis (p=0.248) and Flat feet (0.564) no statistically significant differences were determined. All of the female participants had lordosis, so this variable was not analyzed in the Chi square test.

DISCUSSION

The measurement results indicate a high level of prevalence of physical deformities among the female basketball players, senior competitors in the First league of Serbia. Analyzed based on the location of the deformity on the body of the players, the most prevalent deformity is located on the spinal column in the lumbar region in the sagittal plane, also known as lordotic posture, which is found in all the female participants (100%). In addition to this deformity of the spinal column, scoliotic posture was also quite prevalent, in as much as (91.7%) of the participants. Among the deformities localized in the leg region in the frontal plane, the most prevalent are bowlegs with as much as (91.7%) while only one of the participants (8.2%) was knock-kneed. Flat feet were present in as many as (58.3%) of the participants. The remaining deformities were present in a significantly smaller percentage.

These results of the postural status of the spinal column and the arches of the feet are in accordance with the studies carried out on athletes (Radaš & Trošt Bobić, 2011; Đurić, Janićijević, Majstorović & Ilić, 2015; Grabara, 2016; Jandrić, 2016). Athletes represent a group of the population which due to increased physical activity, which in the case of elite athletes far exceeds the limits of recommended, healthy levels, which along with a specific technique or muscle activation may lead to the occurrence of a muscle disbalance. A muscle disbalance is more present in sports whose performance technique is conditioned by the asymmetry of movement on both sides of the body, as well as the position or primacy of the upper or lower extremities. In accordance with previous research results, but also the data obtained in this study, we could explain the high percentage of lordosis with the dominance of the technical element of the block and defense, as well as the contact part of the game during which for a more stable position, the legs are placed wider than shoulder width with a more taut musculature in the lumbar region of the back, which is more often found among the female players whose anthropometric parameters do not provide an advantage in the game. The results for the posture of the spinal column in the frontal plane, that is, the occurrence of scoliosis which is exceedingly frequent (91,7%) could be explained by the specific nature of the performance technique of leading the ball with the dominant hand, which leads to the strengthening and shortening of the musculature of one side of the body, that is, the side of the body which is performing the technical element of leading the ball, with the simultaneous stretching and weakening of the musculature of the opposite side of the body, which leads to a muscle disbalance and the emergence of the deformity at a functional level. Also, a high prevalence of the deformity known as bowlegs may indicate more prevalent technical elements of low leading the ball with changes in direction and stopping during the game, where the inertia is extensive, and the knee joint suffers extensive lateral resistance which leads to a further strengthening of the adductor muscles, that is, the medial muscles of the legs, and the simultaneous weakening of the muscles on the lateral side of the legs.

The results which pointed to a difference in the prevalence of body deformities among female basketball players of the First league of Serbia indicated a statistically significant difference (p=0,004) in deformities such as lordosis, scoliosis and bowlegs in favor of the participants with the deformity, which had previously been indicated in the descriptive analysis and explained in the previous part of the discussion.

In accordance with the aforementioned, there is a clear message for the coaches of elite athletes regarding the severity of the occurrence of deformities as a result of the performance of technical elements, asynchronous and non-cyclical sports, that is, sports whose performance techniques are focused on the unequal prevalence of the muscles of the left and right side of the body, as well as the activation of only the upper or lower extremities. In addition, the recommendation to coaches is that it is necessary to plan the space in the training process of female basketball players both on the macro and mezzo and micro level of performing movements which activate the musculature which is non-dominant in the sports technique applied during preparations for competitions and the competitions themselves.

CONCLUSION

The results obtained in this study indicate an unexpectedly high level of the prevalence of deformities both of the spinal column in the frontal and sagittal plane and the legs in the frontal plane, while the status of the feet is present in slightly more than one half of the female basketball players. These results indicate that physical inactivity is not the sole parameter for the emergence of physical deformities during our life, and that excessive physical activity with the dominant use of a particular side of the body can cause excessive power of one side of the body and lead to a muscle disbalance, that is, the emergence of deformities. Based on the knowledge obtained on postural status, we can conclude that frequent control and monitoring of the postural status of elite athletes is necessary for the equal development of the musculature of the entire body, both during the preparatory period and during competitions. The necessity of strengthening both sides of the body is especially relevant for sports where the specific nature of the technical elements is related to the dominant side of the body. Furthermore, the obtained results indicate the necessity for new studies on the postural status of elite athletes.

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Physical Education

THE IMPACT OF DEVELOPMENTAL GYMNASTICS PROGRAM ON THE BALANCE OF THE YOUNGER SCHOOL AGE GIRLS

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SUMMARY

The aim of this research is to determine the impact of a specific program of developmental gymnastics on the balance of children of the younger school age. The program lasted eight weeks, two training sessions per week for 60 minutes. In order to test the balance ability, nine tasks of the Balance subtest, which is part of the Bruininks-Oseretsky test (BOT-2), were used. This test is designed to evaluate the motor efficiency of children aged 4 to 21 years. The application of the exercise program showed a significant influence of the development gymnastics program on the balance of the respondents, so the authors recommend its use in practice. This program is focused on the development of all basic, motor skills and includes exercises on the apparatus and the floor, as well as the techniques of basic gymnastic elements on all apparatus.

Keywords: Bruininks-Oseretsky test, gymnastics, motor abilities

INTRODUCTION

Only the appropriate level of motor skills enables successful learning of more complex motor tasks, the adoption of skills and the creation of habits. Therefore, the development of motor skills, the acquisition of skills and the development of useful habits should be considered as inseparable factors for the integral development of the child. Nevertheless, it should be emphasized that, due to the limited duration of time and the number of lessons in the curriculum, despite the application of various organizational-methodical forms of work in order to improve the physical development and development of motor skills of pupils at the time of physical education, teachers of physical education are not able to influence the visible improvement of the physical development and motor skills of students.

Motor abilities are those abilities of a person who participates in solving motor assignments and condition a successful movement, regardless of whether they have been acquired by training or not. In terms of motor abilities in gymnastics, the greatest importance belongs to coordination, but equally important is balancing, and flexibility.

Balance, along with other motor abilities, plays a significant role in the successful performance of sports skills, as well as in the prediction of sports injuries (Sabin et al., 2010). Potential relationships between balance and injuries have been highlighted by increased interest in developing instruments (tests, assignments, exercises) in order to develop balance programs and reduce the risk of injury (Sabin et al., 2010; Zech et al., 2010). Balance training is used as part of a rehabilitation program after injuries to the hocks and knee joints (Hrysomallis, 2007; Aleksić Veljković, A., 2016).

Balance is the ability to preserve a stable, appropriate position of the body when it moves - a dynamic balance or a standstill - a static balance. Balance involves coordination and control, which is necessary for everyday life, as well as in sports, and it is to be understood not only as the ability to maintain a position but primarily as the ability to rapidly return to the balance position after its violation in conditions of rest or movement. It is also defined as the ability of a person to maintain the body in a balanced position and to be corrected by movements of gravitational gravity action, which makes it difficult to maintain a balanced position by the action of external irritants. The coefficient of inheritance of this ability is very large and for these reasons, the balance is rather specific and difficult to develop (Kukolj, 2006; Aleksić Veljković, A., 2016)

Motor development is a process through which the child develops motor skills, movement patterns and skills, it occurs throughout his life. The changes have been most visible in young children and should be monitored and compared with the typical phases of motor development of children that are characteristic of a certain age. It takes place in a continuous process of modification due to the interaction of different factors (Malina, 2004), and these factors are: neuromuscular maturation, which has a significant genetic component, characteristics of child growth, pace of physical growth, maturation and biological development, effects of previous motor experiences, and prenatal experiences and new motor experiences.

Correct and regular physical activity in children of the younger school-age affects: proper growth and development and improves the child's adapting to society, the state of health of the child, the development of motor skills, which creates the basis for the adoption of more complex skills and psychic abilities, since children satisfy their needs for movement that they are less prone to nervousness, depression, and tension (Milanović & Stamatović, 2009).

The period of the young school age is a very sensitive phase for the majority of authors to improve motor skills and during this time period, if the developmental effects in this area are to be achieved, their stimulation with appropriate physical exercise should be achieved. The younger school age is a very important sensitive period for the development of motor abilities in general, and especially when it comes to learning and adopting a broad repertoire of motor skills and activities. The child of this age is quite independent when it comes to physical activity, and its coordination, balance, and precision improve over time, along with speed, strength, and durability.

One of the basic sports recommended at this age is gymnastics. Artistic gymnastics affects the development of motor skills: strength, coordination, flexibility, and balance. In coordination terms, gymnastic elements are classified into the most complex movements. Testing and periodic monitoring of the ability of young athletes is also important for defining training programs adapted to the requirements of sports and age. In this way, a harmonious and optimal development of fundamental motor abilities is achieved in accordance with the physical development of an athlete (Arruda & Farinatti, 2007; Carrick et al., 2007).

When it comes to developmental gymnastics, the performance of balance positions requires overcoming the inertia of the previous movement and stopping in a certain position with the support. In order to maintain balance, it is important to set the center of gravity of the body relative to the surface of the support. The body weight of the body is farther away from the surface of the support, or it is reduced, making it more difficult to hold in that position. Performing balance positions requires certain agility and nervous-muscular coordination. The aim of this research is to determine, through a certain potential influence of a specific program of developmental gymnastics, through the differences between initial and final exercises.

METHODS

Subjects

The study included a total of 23 girls aged 7 to 9 years old, who at the beginning of the study were members of the gymnastics club "Olimp" from Knjazevac. In addition to regular physical education activities in the school, the group was subjected to a program of developmental gymnastics lasting 8 weeks, 60 minutes twice a week. The development gymnastics program focuses on the development of basic motor abilities, consisting of exercises for the development of motor skills through exercise on machines and ground, and learning techniques of basic gymnastics elements on each apparatus.

Procedure

For the measurement of children's balance, the Bruininks-Oseretski test for motor efficiency, second edition (BOT-2), was used (Bruininks & Bruininks, 2010). BOT-2 is designed to: (a) determine the level of motor efficiency of young people between 4-21 years; (b) detecting difficulties on the move; (c) contributes to the design and evaluation of different training programs.

The Balance subtest assesses the skills of controlling attitudes, movements and movements. The Balance subtlety contains nine tasks:

1. Standing with feet on the line - eyes open (SSOO);
2. Footsteps on the line - eyes closed (SSOZ);
3. An attitude on one leg on the line - eyes open (SJOO);
4. Moving forward in the line with open eyes (HLOO);
5. Walk forward along the line so that the fifth one touches the fingers of the second foot (HLJD);
6. An attitude on one foot on the line - Closed eyes (PSC);
7. Position on one leg on the lower shaft - eyes open (SNOO);
8. Stand with one foot behind the other on the low beam (SJNG) and
9. Position on one leg on the lower shaft - eyes closed (SJNZ).

Statistical analysis

All data analyses were performed in IBM SPSS Statistics 19.0 statistical program. The following basic central and dispersion parameters were calculated: Minimum (Min) value, Maximum (Mah) value of the result, Arithmetic mean (AS), The curvature of distribution is determined by the coefficient of asymmetry ("Skunis"), and the distribution is distributed through the coefficient of flattening ("Kurtosis"). For the determination of statistically significant differences in the mean values of the results on the initial and final measurement, the T-test for the dependent samples was applied.

Experimental program

The experimental program was implemented during 2018 in a period of eight weeks in the gymnastics club in Knjaževac. The aim of the training process was to influence the improvement of balance, but also to help pupils to learn some basic gymnastics elements. The gymnastics program was conducted two times a week. Each session lasted for 60 minutes. All workouts were supervised by trained artistic gymnastics instructors and a PE teacher. Each class unit contained three training phases: First phase started with a warm-up which included slow running and stretching and ended with a polygon with different kind of movements and different games for motor learning of children this age. This was followed by a set of gymnastic exercises. The third phase of a class was the focus on restoring the normal level of emotional, mental and physiological bodily functions and re-establishing the same state that the pupils were in before the beginning of the practice period. The experimental treatment included basic gymnastics skills, according to apparatus available at the moment: acrobatic, vault, mini trampoline, parallel bars.

RESULTS WITH DISCUSSION

This chapter presents the results of research and interpretation of the obtained data by following the order of the data processing methods. The basic descriptive statistical parameters of all the variables included in the survey are included. Table 1 shows the central and dispersive parameters of the distribution of motor abilities of pre-school children at initial measurement.

Table 1. Descriptive statistical parameters at initial measurement

Вар.	Min.	Max.	Mean		SD	Skew.	Kurt.
ССОО	1.00	4.00	2.78	.24	1.17	-.29	-1.44
ССОЗ	1.00	4.00	2.04	.18	.88	.35	-.64
СЈОО	1.00	4.00	2.00	.17	.79	.59	.38
ХЛОО	1.00	4.00	2.78	.21	.99	-.12	-1.13
ХЛЈД	1.00	2.00	1.61	.10	.49	-.48	-1.95
СУЗО	1.00	3.00	2.17	.10	.49	.47	.90
СНОО	1.00	3.00	1.43	.12	.59	1.00	.16
СЈНГ	1.00	3.00	1.96	.12	.56	-.03	.67
СЈНЗ	1.00	2.00	1.83	.08	.39	-1.84	1.52

N - number of respondents, Min - minimum score, Max - maximum score, Mean - mean value, SD - standard deviation, Skew. - coefficient of asymmetry, Kurt. - coefficient of curvature

Table 2. Descriptive statistical parameters on final measurement

Вар.	Min.	Max.	Mean		SD	Skew.	Kurt.
ССОО	2.00	4.00	3.26	.16	.75	-.48	-1.00
ССОЗ	2.00	4.00	2.78	.12	.59	.09	-.20
СЈОО	2.00	4.00	2.83	.16	.78	.32	-1.22
ХЛОО	2.00	4.00	3.17	.14	.65	-.18	-.46
ХЛЈД	2.00	4.00	2.96	.16	.77	.08	-1.22
СУЗО	2.00	4.00	2.56	.12	.59	.45	-.61
СНОО	2.00	4.00	2.65	.16	.78	.72	-.89
СЈНГ	2.00	4.00	3.09	.12	.59	-.01	.16
СЈНЗ	2.00	4.00	2.91	.12	.59	.01	.16

N - number of respondents, Min - minimum score, Max - maximum score, Mean - mean value, SD - standard deviation, Skew. - coefficient of asymmetry, Kurt. - coefficient of curvature

Table 3. Differences between initial and final measurement of motor abilities of children (T - test for small dependent samples)

Variable	t	df	Sig. (2-tailed)
SSOO	-3.867	22	.001
SSOZ	-5.147	22	.000
SJOO	-6.876	22	.000
HLOO	-3.761	22	.001
HLJD	-9.986	22	.000
SUZO	-2.598	22	.016
SNOO	-5.183	22	.000
SJNG	-6.653	22	.000
SJNZ	-8.740	22	.000

Table 3 shows the differences between the balance variables on the initial and final measurement. A statistically significant difference at the level of $p<.05$ was determined for all variables. Such results indicate that the implemented program is very efficient and leads to the progression of all tested variables of the balance of preschool girls. A detailed description of the exercise program is provided in the Research Enclosure. Similar to previous research, the program has shown that it is extremely effective and has contributed to the advancement of all abilities, even after a ten-week program (Deli, Bakle & Zachopoulou, 2006).

What is specific to research in the field of sports gymnastics is a small number of respondents who participate in the research. They are mostly top competitors, representing a representative sample. However, in order to contribute to the improvement of gymnastic training, research into the specificity of the balance in gymnastics in younger age categories is necessary. This is important because of the importance of balance in achieving success in gymnastics, but also in the prevention of injuries, because the connection between balance and sports injuries has been proven in numerous studies.

Although there are a large number of papers that examined specific physical exercise programs on the development of motor abilities of pre-school children who do not have any health problems, a greater number of papers have examined the effects of different exercise programs in children who already have some health problems or are lagging behind in motor development due to various types of disorders (Rajović, 2016). A number of transversal design studies examined the correlation between the overall physical activity of children and the level of their motor skills. These studies have shown that children with higher levels of physical activity have better motor skills. There is a need for more longitudinal studies on pre-school children (Rajović, 2016).

The aim of the research Rajović (2016) was to determine the effects of the NTC (Nikola Tesla Center) physical exercise program on the development of motor abilities of pre-school children. A longitudinal study was conducted in a national kindergarten with two parallel groups, one of which implemented the NTC exercise program for 6 months, while the second group applied for a common exercise program. It was found that children from the experimental group made significant progress in the examined motor abilities, which confirmed the effects of the NTC Physical Exercise program on the development of motor abilities of pre-school children.

It is very important that all physical activities in preschool institutions are best exercised through the game because it is one of the basic and natural children of need. Children learn about the world through the game of skill, fantasize, create, acquire friendship and social relations (Stojanović, 2016). It is therefore very important, from the earliest age, to provide the child with space and time for movement and playing, in order to achieve positive habits and lifelong love for sports. Our training program, therefore, included games designed to develop motor skills and abilities in accordance with the age of children. Research Stojanović (2016) confirmed that there are statistically significant adaptive changes in motor skills under the influence of programmed exercise in pre-school subjects for six months, so our research was aimed at determining whether changes would occur if the program was shorter, for a total duration of 12 weeks. It has been proven that with the intensity, duration, and frequency of programmed exercise, we can provide an effective way of continuous improvement of motor abilities in pre-school children.

While the general, short-term goal of the physical exercise program is to encourage integrative child psychophysical development, it is important to emphasize that the long-term goal is to accept useful and healthy habits important for life. The purpose of this program is to develop habits for regular exercise in the future, a healthy lifestyle, and love for different sports. Therefore, it is most important to develop initially positive attitudes of children towards sports activities and/or everyday physical exercise. Improving motivation and improvement in the overall developmental status of a child can facilitate later selection of talented individuals for certain sports disciplines or can only be a good basis for a sportive active lifestyle in adulthood.

Similar to our study, Kayapnar (2010) aims to evaluate the effects of exercise programs, but only the dynamic balance in pre-school children (5-7 years of age). A group of 80 examinees was divided into experimental (20 girls and 20 boys) and a control group (20 girls and 20 boys). The experimental group was included in the program for 1h, three times a week, for three months. The experimental program included exercises for development of motor skills, post exercises and games for children. The differences in the results between the experimental and the control group were obtained using the t-test at the significance level ($p <.05$). The results showed that there was a statistically significant difference between the first and post-test ($p <.001$) in the experimental group, while in the control there was no significant difference ($p <.05$). Between the final testing, there were differences in favor of the experimental group ($p <.001$). The results indicate the positive effects of exercise programs on the dynamic balance in pre-school children.

Another Altnkök study (2007) on a sample of preschool children (5-6 years of age) showed the positive effects of a four-week program on improving the static balance (significance level $p <.001$). In the control group, the result of the first test was 28.03 s, while the second was 23.79 s. In the experimental group, pre-test and post-test values were 28.09 s and 41.55 s.

Study of Kiomourtzouglou et al. (1997) found that there was a statistically significant difference in maintaining the static balance, in favor of a group of athletes who were involved in the rhythmic gymnastics program compared to the control group. The sample consisted of children aged 9 to 15, and the author's conclusion is that the ability to maintain balance is growing as well. Author Yldrm (2007) found improvement in the static balance in children aged 5 to 10 who were involved in a gymnastics program for two hours over eight weeks. The improvement in the experimental group was at the level of significance $r <.001$ between the pre and post-test values. At the first test, the mean value on the static balance test was 2.68 s, while on the post-test 4.18 s. Atilgan (2013) explores the effects of 12-week trampoline exercise programs on static and dynamical balance, vertical jump and foot force in boys, non-adherents, ($n = 28$) ages 9 to 10 years. In the experimental group there were 15 and in the controlling 13 boys. The results indicated significant differences ($p <.05$) between the experimental and control group variables. Training for 12 weeks on a trampoline significantly influenced the improvement of the static and dynamic balance results and the vertical jump performance, while there was no improvement in the balance on one foot. The authors recommend training on trampolines to improve the balance and vertical jump in children.

CONCLUSION

This research involved 23 children aged 7 to 9 years old, who at the beginning of the study were members of the gymnastics club "Olimp" from Knjazevac. In addition to regular physical education activities in the schools, the group was subjected to physical exercise for eight weeks, 60 minutes twice a week. All balance tests used in the research can be applied without additional material resources, for periodic monitoring of this ability and further progression.

Twelve weeks of gymnastics training implemented in PE classes had a beneficial effect on abdominal strength, flexibility, aerobic fitness and upper and lower body strength in adolescent pupils. Therefore, participation in gymnastics must be recommended as a positive foundational activity for school-aged children, from early childhood to adulthood. Data provided in this study represent useful information because of the norms of the physical test in adolescent pupils, which should be helpful for practitioners conducting similar physical function testing in the future.

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MOTOR ABILITIES OF CHILDREN OF YOUNGER SCHOOL AGE (OVERVIEW)

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SUMMARY

Positive results of transformational processes could be expected if education program is better adjusted to the motor skills of students and their individual characteristics. The purpose of this study was to examine and summarize research that focuses on motor abilities of children. The method involved the meticulous collection and analysis of the relevant literature published between 2007 and 2018. The search was conducted by using Google Scholar and PubMed. The findings indicate that the researched psychical education programs have better effects compared to the standard physical education, and that children with more optimal BMI achieve better results. It could be concluded that there is a need for a complete reform of physical education and for the introduction of additional physical education classes.

Keywords: physical education, skills,abilities, obesity, elementary school, extracurricular activities

INTRODUCTION

Physical education is a pedagogical process that employs the use of physical exercise in order to systematically contribute to the holistic development of students' bodies, improved health and the development of physical and moral characteristics. The concept of physical education in elementary schools is characterized by students' active participation in the education process, and all for the purpose of the fulfillment of their own interests. The main goal of physical education is to systematically and purposefully make a positive contribution to the psychosomatic state of students and to create conditions for the optimal student development. In addition, it is important to provide students with a means to maintain and check their health and physical skills on their own (Kocic et al., 2009).

It is important that the physical education program is adjusted to individual student characteristics. If one uses the same program for different subjects who have different individual needs and characteristics, it may have negative consequences on the body and may have some positive results only for the very few (Krsmanovic, 2000). In order to significantly influence the anthropological characteristics of students, it is necessary to select generic physical exercises as part of physical education and to utilize them with a much greater intensity compared to the current practices. More specifically, it is necessary to infuse a higher degree of the sports principles and methods into the actual physical education program and to adjust it to the children of elementary school age in order to address general motor skills and behaviors (Bala, 1991).

Motor abilities are defined as abilities that are involved in the fulfillment of motor tasks and successful movement regardless of whether these skills are acquired by practice or not (Malacko, 1991).

METHODS

Literature review

For the collection, classification and analysis of the selected research, a descriptive method was used. The literature was systematically collected by performing searches of the following databases: Google Schoolar, PubMed, and KoBSON. The search was limited to the studies published between 2007 and 2018. Books with the relevant topic were also used for the purpose of this study. The key words used during the search were: physical education, skills, obesity, school, extracurricular activities. In addition, references of the examined literature were also checked in order to learn about additional studies on this topic.

Literature selection

The selection of actual studies was determined on the basis of their title and key words. A set of specific search criteria were established. The first criterion was that the study examines motor skills of elementary school aged children, that the studies were published in the last 11 years, and that samples were children Grades 1 to 5, that there were no missing data, and that the studies were peer reviewed.

The process of literature extraction

The study included 16 tightly related research papers. At the beginning of the search, 770 references were identified, which corresponded to some of the predetermined criteria, but based on their age, 215 studies were eliminated, and them an additional 91 studies were eliminated because of the publication date requirement. The rest of the studies were eliminated based on other criteria (Figure 1).

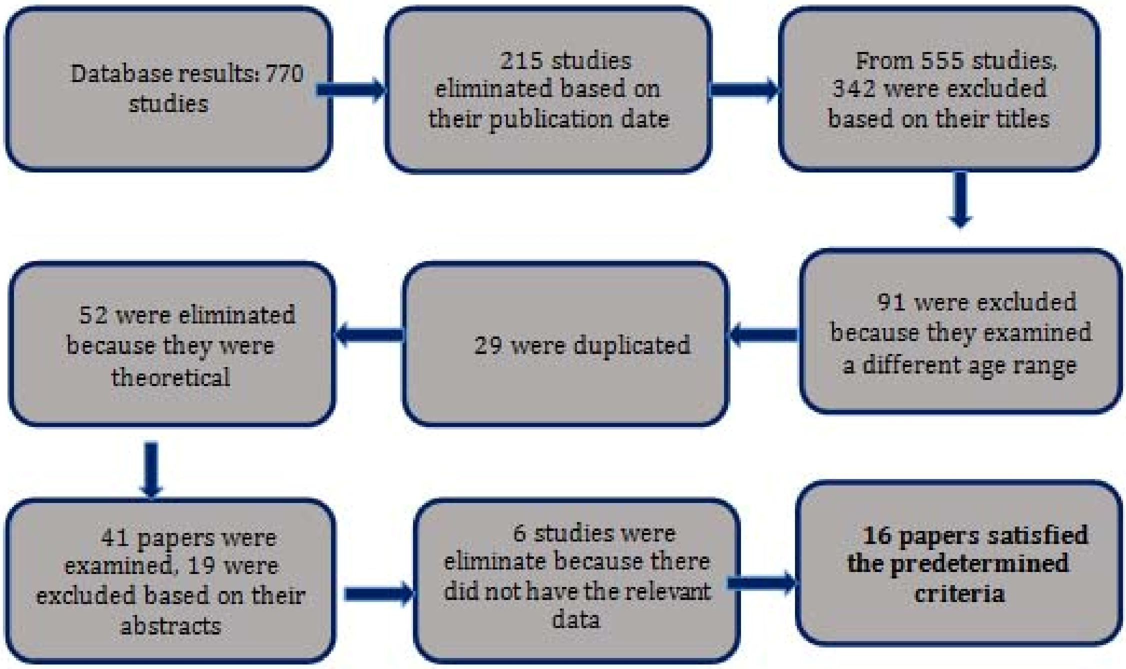

Figure 1 – Graphical representation of the search process and literature extraction

RESULTS

Table 1 contains the examined studies. It contains information about the first author, publication year, sample size, gender, age or grade, location of students, variable samples and the purpose and results of each study. The number of students ranged from study to study, with the smallest number of participants being 48 in research Vuleta, D., Milanović, D., & Ćaćić, L. B. (2013), and the study with the largest number of participants 757 was conducted by Đokić, & Međedović, (2013). The youngest students were in Grade 1 in the study by Sabolč, H., & Lepeš, J. (2012) и Zrnzević, N., & Zrnzević, J. (2018), and the oldest students were Grade 4 in the study by Struza-Milic (2009). In nine studies, the samples consisted of both male and female students, three had only female participants, and four studies had only male students. A test most commonly used for the estimation of motor abilities was a long jump, used in 12 out of 16 studies.

Table 1. Summary of the existing literature

First author and publication year	Study sample: Number of students Gender (M/F) Age or grade Location	Study purpose	Program duration	Study results
Grbavac, (2007).	249 students M 7 years ± 2 mounts Bosnia and Herzegovina	The study of dynamic of relational changes of the structure and morphological characteristics and MA in the defined age range.	School year	The growth of bone segments could be related to motor ability and to almost all motor dimensions.
Milanovic, (2007).	538 s $C_{1(IV)}$-M=74;F=52; $E_{2(III)}$ M=101;F=82; $C_{1(IV)}$-M=58;F=51; $C_{2(III)}$ M=74;F=46 III - IV grade Belgrade	As a means, does an organized polygon format have a primary role in increasing the effectiveness of the education process in elementary school aged children.	14 working weeks	The programmed education had positive effects on motor abilities of students. Statistically significant differences compared to the control group. Obtained by using test for speed, agility, flexibility and coordinated ability.
Jurak, (2007).	328 s E=157; M=81;F=76 C=171;M=87; F=84 7-10 years Slovenia	To determine that the program of additional hours of physical education affects the physical and motor development of children.	3 years	There are significant differences in both sexes in favor of E group versus C.
Selmanović, (2008).	87 s M C=42; E=45 11years ± 6 mounts Croatia	Influence of additional volleyball program on changes in variables for assessment of students' MA.	School year	There is an increase in arithmetic mean between the initial and final states in almost all motes. variables.
Struza-Milic, (2009).	503 s M=262; F=241 IV grade Vrsac	Possibilities for identifying motorized gifted students in the physical education of motor testing and recognition techniques	/	Potentially motorized girls and boys are stats. significantly more engaged in sports than boys and girls from the C group.
Cetinić, (2010).	400 s M=200; F=200 7-10 years Croatia	To determine the current state of anthropometric features, MA and motor achievements in students in the early school year.	/	The results in motor tests are better in all tests than in the long-range jumping test in girls and the polygon retraction test in a boys.

First author and publication year	Study sample: Number of students Gender (M/F) Age or grade Location	Study purpose	Program duration	Study results
Aleksić, (2011).	102 s F 9-10 years Nis	To determine the efficiency of specially programmed physical education (with an emphasis on deve-lopmental gymnastics) on the transformation of some anthropological characteristics. (MA - static power).	School year	Experimental treatment has achieved a corresponding effect on the transformation of MA, static strength, pupils of the younger school age.
Džibrić, (2011).	153 s F C_1=48; C_2=56;K=49 8 years ± 6 mounts Tuzla	Identify the effects of different physical and health education on MA students.	half a year	There is a statistically significant difference in the overall motor space between the three groups of girls surveyed.
Sabolč, (2012).	125 s M=62; F=63 I grade Subotica	To determine the effects of anthropometric characteristics and body composition on the MA of boys and girls of the first grades.	/	There is a stat. a significant difference in motor variables (20m from high start, polygon backlash, and long jump from the city) for the benefit of boys, and the precession in the sedu multiplied for the benefit of girls.
Đokić, (2013).	757 s M=379; F=378 III - VI grade Sremska Mitrovica	Estimation of nutrition, based on BMI, and motor status using 8 variables.	School year	Children who are overweight and obese have significantly reduced motor abilities compared to normally nourished children, especially in the domain of strength.
Prodanović (2013).	166 s M=86; F=80 6-7 years Memici i Zivnica	Determination of differences in dimensionality of morphological characteristics and MA of students in elementary school.	/	Boys have more pronounced transversal. dimensional, and a girl more than% subcutaneous fatty tissue. Stats determined. differences between boys and girls in most motor variables, except in fleks. hull and foot speed.
Svraka, (2013).	86 s M 9-10 years Banja Luka	The influence of regular physical education in combination with additional sports activities at school and	half a year	It is possible to improve the results in some MA with this combination.

First author and publication year	Study sample: Number of students Gender (M/F) Age or grade Location	Study purpose	Program duration	Study results
		outside on MA.		
Vuleta, (2013).	48 s M E=21; C=27 8 years Croatia	Influence of the mini handball program and the teaching of physical and health culture on the changes of MA of students of younger school age.	3 months	The mini handball program produced a lot of statistically significant differences in motor skills in relation to the teaching of physical and health culture.
Đorđević, (2014).	75 s F 7 years Nis	Determine whether there is a correlation between anthropometric characteristics and motorism in normal and over-nourished girls.	1 measureme-nt	The body, volumidity and subcutaneous fat tissue are a ballast mass that complicates the realization of tumor problems that require lifting or weight transmission.
Marković, (2016).	209 s M/F E=105;C=109 third grade Uzice	Determine whether an alternative program of teaching physical education can completely replace the existing one and contribute to achieving the necessary goal and tasks of teaching physical education.	6 months	The alternative program had positive effects in achieving the goal and tasks of teaching physical education. Significant differences in the results of the measurements compared to the regular program.
Zrnzević, (2018).	185 s M/F E=106; C=79 first grade /	To determine the effects of the applied experimental and the existing physical education program on MA of Grade 1 students.	School year	A statistically significant difference in all the studied variables between pupils E and C groups.

M – male; F – female; s – students; C - control group; E - experimental group; MA - motor abilities; BMI - body mass index.

DISCUSSION

Djoklic and Medjedovic (2013) studied the body mass index (BMI) and motor status of 757 students in Grades 3 and 4. The findings suggest that elementary school aged children are at risk from Grade 1, with Grade 3 and 4 students being at the greatest risk – 35% of students being either underweight or overweight. However, this number decreased as the student age increases. With regard to motor skills, lower level of motor skills in obese and overweight children was associated with muscle deficiencies, which in turn negatively impact posture and may contribute to the development of physical deformities. Motor skills were correlated to the posture of lower extremities and feet. It was determined that in children ages 9 to 12 these body parts maintain the structure of feet. The recommendation from this study was to suggest exercise for the strengthening of back and stomach muscles for children with lower level of motor ability and higher BMI.

Svraka (2013) conducted a study on 86 students ages 9 and 10 in order to learn whether a regular physical education program in combination with extracurricular activities for students in and outside of school contributes to a significant change in motor skills. The results indicated that it is possible to significantly improve the movement speed and expressive leg power by combining physical education with additional athletic activities. It is suggested that the main contribution was due to activities in different individual and team sports which impact the development of speed and explosive abilities. The author states that one should interpret these results with caution because of the relatively small sample size and the nonexistence of the control group.

Struza—Milic (2009) researched a possiblity of identifying gifted children in the area of motor abilities by their teachers on a sample of 503 Grade 4 students. The teachers successfully identified 55,2% possibly gifted students in the area of motor abilities, which is similar to other similar studies. These finsidngs indicate that there is a a lot of room for improvement with respect to the techniques used for identifying gifted students.

Prodanovic, Sljivic, Kurtovic, Kurtovic, & Devedzic (2013) – On a sample of 86 male students and 80 female students in Grade 1, these authorsd studied the gender difference in the dimensionality of morpholigical characteristics and motor abilities. They found a statistically significant difference between boys and girls on most of the motor-spacial variables, expect on the variables of torso flexibility and the speed of legs. These findings conform that boys are more active and better prepared for competitive sports and that they achieve better results on the tests of motor abilities.

Sabolic and Lepes (2012) – On a sample of 125 students, 62 male and 63 female participants in Grade 1, they measured basic antopometric charactericts, which in this age period may be relevant contibutors to the development of motor abilities. The results showed that boys were faster in terms of running speed and the coordinating power develped during running, jumping, and climbing, while girls schored higher on flexibility measures and precision due to their finer and more precise movements (Matic, 2008).

Grabavac, N (2007) – This author studied 249 meale students in Grade 1. According to the obtained results, students whithout bigger ammount of fat tissues and without pronounced mucsle volume at the beginning of school year had an easier time performing a whole series of motor excerices.

Milanovic (2007) – This paper examined the role of methodical-organizational polygon format in increasing the efficacy of educational process with students of younger school age. The sample was comprised of 538 students in Grades 3 and 4 who were divided in K and E groups. There were statistically significant differences due to the experimental factor. The author suggests that a mandated physicial education in youger grades would contribute to the increase in the effects of physical education among students in these age group.

Jurak, G., Kovac, M., Strel, J. (2007) – The purpose of thos study was to find out if additional hours of physical education made a difference in the motor and physicial development of childre ages 7 to 10 years. The sample consisted of 157 stduents of both genderds in group E (experimental sports class) and of 171 students in group K (control group). The results of this 3-year longitudinal study revealed that the experimental group had com higher results compared to the control group. This study showed that children in the sports class had a better motor status and that their parents had a more positive attitude toward sports.

Selmanovic, Milanovic, & Hrzenjak (2008) – The authors studied 87 male students who were around 11 years of age in order to find out the impact of additional volleyball training on the development of motor abilities. The variables that significantly contributed to the positive change in the motor space of the K group are: long jump, backwards polygon, and hand tapping.

Cetinic, J., & Pateric, V. (2010) – The purpose of this study was to measure current state of motor abilities and motor accomplishments in students of early school years. The sample consisted of 400 students (200 male and 200 female students) ages 7 to 10 years. The results indicated that on almost all test the male students outperformed the female students.

Aleksic, Mekic, & Tosic (2011) – These authors wanted to examine the effects of a special physical education program on the the transformation of motor abilities in 102 girls ages 9 and 10. The experimental program with elements of developmental gymnastics showed to be an effective means that could impact the transformation one of the three variables that define the motor space of repetitive power.

Dzibric, D., Pojskic, H., Ferhatbegovic, A., Ganic, E., Hasanbegovic, S., & Terzic, A. (2011) – On a sample of 153 female Grade 3 students divided into 3 subsamples, the authors examined the effect of different physical education programs on the basic motor abilities. This was accomplished by the application of 9 motor tests, an dthe results revealed a statistically significant difference among the three groups, with the experimental groups having the highest score. Thy is study confirms a need for the introduction of specialized physicial education programs into younger grades and professionals who would teach these programs.

Vuleta, D., Milanovic, D., & Cacic, L.B. (2013) – The puspose of this stu dy was to analyze the effects of a mini handball program on the changes in motor abilities in 48 male students (21 in experimental and 27 in control group). Based on the results on the final test, the participants in the experimantal group showed a significantly higher improvement in the indicators of basic motor skills compared to the participants in the control group. The generalization of these results are limited given a relatively small sample size.

Markovic (2016) in his study intended to determine whether alternative programs of physical education could completely replace the existing program and constributed to the fullfillment of the goals of the regular physical education program. The sample consisted of 214 students in Grade 3 of both genders, with 109 students in the experimental and 105 in the control group. Although there was no statistically significant difference between the two groups, the alternative program was deemed as successful and could be used as an alternative to the regular established physicial education program.

Zrnevic, N., Zrnevic, J. (2018) – The purpose of this study was to find out about the effects of an experimental and the existing physical education program on the motor abilities of Grade 1 students. . There was a total od 185 students, 106 in the experimental and 79 in the control group. The control group had higher final schores. This indicates that the standardized physicial education program needs to be restructured and adjusted to the needs of the present day. This study also suggests that in the eary school period, it is improtant to work on the development of motor abilities especially those that are genetically predetermined.

CONCLUSION

In this paper that involved a meticulous review of relevant literature, the total number of the examined sample was 4011 students, 1934 male and 1683 female students. The reviewed papers were published in the period of 2007 to 2018. Some studies had both experimental and control groups, whereas some only had an experimental group. Most studies utilized tests that assessed the development of motor abilities in students.

The main focus of the examined studies included the analysis of the effectiveness of polygons as a methodical organizational form, additional physical education classes, specialized physical education programs, body composition, as well as anthropometric characteristics on motor abilities in children of younger school age.

The purpose of this study was to examine the effects of control and experimental groups on motor abilities in young school-age children. Through the review of all relevant literature and the selection of 16 studies that were most pertinent to the topic in question, it could be concluded that there were positive effects in all of the studies. In most studies, there was a statistically significant difference between the control and experimental groups with respect to motoric. It is also noteworthy that the studies shed light on the importance of expert educators (for physical education), specialized physical education programs, and additional extracurricular physical activities on the development of motor abilities in children and on their overall health and development.

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ATTITUDES OF TEACHERS AND PROFESSORS ABOUT INCLUSION IN PHYSICAL EDUCATION TEACHING

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SUMMARY

Introduction: By the law of the basics of the education and upbringing (2009) everyone has the right to education and upbringing without discrimination and separation by gender, race social, cultural, religious or any other class , a place of residence or health condition, disabilities (physical, cognitive, emotional). All children have right to physical education, so in the frame of basic teaching systems, physical education is represented as compulsory subject in 80% primary schools in the world. It is expected that physical education class to be one of the most supported and the most productive element of the inclusive process in school. The goal of the work was to investigate teacher and professor statements about inclusion in teaching physical education in primary school age.

Methods: The research has transversal character and it was realized in the second term of 2017/2018 school year in 18 primary schools on the teritory of the region of Pomoravlje. Reasearch involved 60 teachers and 60 professors of Physical education. For the estimation of attitudes of teachers and professors of Physical education the instrument from the previous research was used, Greek scale Attitudes towards Teaching Individuals with Physical Disabilities in Physical Education (Kudlacek, 2002) which was filled in by teachers during regular Physical education lessons.

Results: The largest number of teachers and professors work in school between ten and twenty years, and the least ones are the ones who have worked for five years. High professional education prevails in relationship of higher and master education which is less represented. There are 81.7% of professors and teachers 60,7% who did not attend inclusion seminars. There is only just 8.7% of professors and 49.2% of teachers who have previous experience in working with children with disabilities. Most of the teachers (71.4%) think that they are competent in involving children who are disturbed in development in comparison to professors (41.4%), Including students with special needs in classes will make teaching much complicated and 49.0% of teachers think that they are not compentent enough, while 41.4% of teachers do think they are competent. 48.8% of professors and 34.6% of teachers do think they are competent in including students disturbed in development need in order to encourage students to learn how to help others. Most of the professors think that their inclusion will make other students more tolerant and think of themselves as competent. Inclusion in the proces of regular physical education will have positive effect in development of a personality in students who are disturbed in development but 49.4% of professors and 54.6% of teachers think that they are not competent enough. Those who think they are competent enough to stop discrimination of students disturbed in development are 34.7% of professors and 35,7% of teachers . The same relation is in statement that the flow and the dynamic of classes would slow down. Active participation of students who are disturbed in development would encourage students to achieve better knowledge about that people and for that 43.3% of professors and 36.2% of teachers think of themselves they are competent. The same percent is in affirmation that this inclusion can teach other students to be more cooperative.

Conclusion: The general conclusion indicates that the situation in primary school physical education lessons is very complex considering inclusions and that the attitudes of the teachers are statisticaly significantly different in four out of ten statements.

Key words: attitudes, inclusion, teacher, a teacher, primary school age

INTRODUCTION

According to the law of the system of education (2009) the right for education and upbringing is equal for all without discrimination by gender, race, social, cultural, religious or any other class, place, material or health status, disabilities (psysical, cognitive, emotional). According to some estimations there are 10% of children in Serbia with some kind of disabilities, many of which are not included into educational system (Rapajic, Nedovic, Ilic and Stojkovic, 2008). Beside elementary school program for regular schools there are individual educational plans, programs and ways of work with children with special needs.

The most common definition of thenclusion is the involvement of children with special needs in regular schools. Apart from this, inclusion represents the involement of the children from the following sensitive groups: the children with disabilities, the children who belong to national minorities, refugees and displaced children, the children without parential care and the children from socialy deprived families (Rapajic, Nedovic, Ilic and Stojkovic, 2008).

Considering the educational system as whole it can be stated that the attitudes towards inclusion are mostly negative. Schools need support which unfortunately cannot be obtained. Two thirds of teachers think that they do not have enough support in working with children with disabilities. The increase of the number of experts in the classroom does not guarantee succees. More systematic training of experts is needed so that the support would be sensible (Avramidis, Baylis & Burden, 2000).

Most students ate the Faculty of Pedagogy have negative attitudes towards students with disabilities. They think that these children should go to special schools školama (Macura Milovanović & Poček, 2011). Also, 10.0% of questioned teachers in primary schools think that it is the best for students with disabilities to attend special schools, while they could attend some lessions in regular classes (Djevic, 2009). In order to create adequate conditions for the educational process of students with the disabilities continuous and systhematic expert support and help for teachers is needed, as well as the change of attitudes of all the participants in educational process towards inclusion (Talmor, Reiter and Feigin, 2005).

All the children have the right to physical education, so that in the frame of general subjects, physical education is present as an obligatory school subject in 89.0% primary schools in the world. It is expected that physical education becomes one of the most supported and most active elements of inclusion process in schools with respect to education possibilities of each student (Rouse, 2009). Positive attitudes of physical education teachers towards inclusion are decisive factor which contributes to the succesful inclusive physical education (Folsom Meek and Rizzo, 2002). In order to change beliefs and attitudes the priority of further development of inclusive physical education would be realized through practical experience and participation in effective programs of training (Ben Yehuda, Leyser and Last, 2010).

Present research indicates that the lenght of working experience does not influence statistically significantly on differences considering former life exprerience and educational expreriences in the work with students with development issues. Some reserchers show that gender has significant role in forming of more or less positive attitude, in which women have more positive relation towards students with development issues (Patrick, 1987). Older teachers of physical education have more negative attitude towards students with disabilities in relation to younger coleagues (Rizzo & Kirkendall 1995). On the basis of the previous results the goal of this work was to research the attitudes of teachers about inclusion in physical education lessens in primary school.

METHODS

The research has transversal character and it was realized in the second term of 2017/2018 school year in 18 primary schools on the teritory of Pomoravski region. The research involved 60 primary school teachers for younger school age and 60 physical education teachers. For the evaluation of teachers attitudes the instrument from the previous research was applied Greek scale Attitudes towards Teaching Individuals with Physical Disabilities in Physical Education (Kudlaček et al., 2002), which was filled in by teachers during regular physical education lessons. The answers were given on the five level scale of Lickert type: I am not competent at all, I am not competent, insufficiently, I am competent and fully competent. In quantitative analysis of the data the percentage research of frequances was applied. For the testing of hypothesis of the significance of differences person's hi-square test (χ^2) was applied.

RESULTS

The data about the examinees show that out of 60 higher grade teachers 36 males and 24 females. The situation is completely different with lower grade primary school teachers, with 45 females and 15 males. Most teachers have working experience between 10 and 20 years, 22 teachers (36.6%), while the smallest number of teachers is with a five year working experience, exactly seven of them (11.7%), and there are nine teachers with a thirty year working experience (15.0%). Most teachers have a twenty year working experience, 27 of them (45.5%). The smallest number of teachers is with five year working experience, only three of them (4.9%). There are 18 teachers with a ten year working experience (29.7%), while 19 of them (19.9%) is with a thirty year working experience.

University degree prevails in relation to college and master degree, which are the least frequent. There are 81.7% of the teachers who did not attend inclusion seminars, 60.7% of lower grade primary teachers. There are only 8.7% of teachers and 49.2% of lower grade primary school teachers who have previous experience in working with children with disabilities.

Table 1. Numerical and percentage frequency of the teachers' answers to certain statements

Statement			1	2	3	4	5	In total
Including students with physical disabilities in my PE class will help students without disabilities to learn to interact with persons with physical disabilities.	HGT	f	0	0	13	25	22	60
		%	0.0%	0.0%	21.3%	41.4%	37.3%	100.0%
	LGT	f	1	1	10	43	5	60
		%	1.7%	1.7%	16.6%	71.7%	8.3%	100.0%
Including students with physical disabilities in my PE class will make teaching physical education more difficult	HGT	f	0	0	13	25	22	60
		%	0.0%	0.0%	21.3%	41.4%	37.3%	100.0%
	LGT	f	4	11	30	14	1	60
		%	6.6%	18.0%	49.2%	23.6%	1.6%	100.0%
Including students with physical disabilities in my PE class will encourage students without to help others.	HGT	f	0	1	12	29	18	60
		%	0.0%	1.6%	19.8%	48.8%	29.8%	100.0%
	LGT	f	2	4	10	21	23	60
		%	3.3%	6.7%	17.7%	34.6%	37.7%	100.0%
Including students with physical disabilities in my PE class will make lesson planning and preparation much more difficult.	HGT	f	0	2	16	30	12	60
		%	0.0%	3.3%	27.2%	49.7%	19.7%	100.0%
	LGT	f	17	23	11	8	1	60
		%	27.9%	37.7%	18.2%	14.5%	1.6%	100.0%
Including students with physical disabilities in my PE class will teach students greater tolerance.	HGT	f	2	6	15	24	13	60
		%	3.3%	9.8%	25.6%	39.7%	21.5%	100.0%
	LGT	f	15	14	8	11	12	60
		%	24.6%	23.3%	14.2%	18.2%	19.7%	100.0%
Inclusion will have a positive effect on the development of personalities of students with physical disabilities (e.g. self esteem, feeling of belonging, etc.).	HGT	f	4	7	30	12	7	60
		%	6.6%	11.5%	49.4%	19.7%	12.7%	100.0%
	LGT	f	6	7	33	8	6	60
		%	9.8%	11.8%	54.3%	14.2%	9.8%	100.0%
Students with physical disabilities will experience discrimination in my regular physical education classes.	HGT	f	5	6	17	21	11	60
		%	8.5%	9.9%	28.9%	34.7%	18.0%	100.0%
	LGT	f	3	6	12	21	18	60
		%	4.9%	9.8%	19.9%	35.7%	29.6%	100.0%
Students with physical disabilities will slow down instruction and progress in my PE class.	HGT	f	6	12	19	14	9	60
		%	9.8%	19.8%	31.4%	24.2%	14.8%	100.0%
	LGT	f	6	11	16	13	14	60
		%	9.8%	18.2%	26.4%	22.5%	23.0%	100.0%
Inclusion will cause my students to have better knowledge about persons with disabilities.	HGT	f	1	4	9	21	25	60
		%	1.6%	6.7%	14.8%	34.6%	42.3%	100.0%
	LGT	f	1	4	9	24	22	60
		%	1.6%	6.8%	15.9%	39.5%	36.2%	100.0%
Inclusion will cause my students to have better knowledge about persons with disabilities.	HGT	f	8	11	9	11	21	60
		%	13.1%	18.2%	15.8%	18.2%	34.6%	100.0%
	LGT	f	9	12	11	11	17	60
		%	15.8%	19.7%	18.3%	18.3%	27.9%	100.0%

Legend: HGT - *Higher grade teachers*, **LGT** - *Lower grade teachers*, **1** - *I am not competent at all*, **2** - *I am not competent*, **3** – *Insufficiently*, **4** - *I am competent*, **5** - *Fully competent.*

Considering Table 1 we can see numerical and percentage frequency of teachers to certain statements. A larger percent of higher grade teachers (71.4%) think that they are competent for having successful communication between students without and students with disabilities in relation to the lower grade teachers (41.4%). The number of higher grade teachers 22 (37.3%), who think that they are completely competent for successful communication. The inclusion of the students with disabilities in lessons will make the teaching more complicated and 49.2% of the teachers think that they are insufficiently competent, while 41.4% of the higher grade teachers think that they are competent. In order to include students with disabilities with the goal of encouraging other students to learn how to help others is considered by 48.8% of higher grade teachers and 34.65% of lower grade teachers. For the planning and preparation of the lessons in which the children with disabilities are involved, thirty higher grade teachers (49.7%) think that they are competent while most lower grade teachers 23 of them (37.7%) think that they are incompetent.

The largest percentage of higher grade teachers think that they are competent that the inclusion of students with disabilities in regular physical education lessons will make other students more tolerant. Only two higher grade teachers (3.3%) think that they are not competent. The largest number of teachers think that they are not competent at all (24.6%) to make other students be more tolerant. The inclusion in the process of regular teaching of physical education will have a positive effect on the development of personality of students with disabilities, but 49.4% of higher grade teachers and 54.3% lower grade teachers think of themselves as insufficiently competent. There are 34.7% of higher grade teachers and 35.7% of lower grade teachers who think that they are competent to prevent discrimination of the students with disabilities. The largest percent of higher grade teachers (31.4%) and lower grade teachers (26.4%) think that they are insufficiently competent to slow down the pace and dynamic of the lessons by the use of different methods in order to involve students with disabilities. The largest percent of higher grade teachers (42.3%) think of themselves fully competent to motivate with their participation the students with disabilities the rest of the students to acquire better knowledge about these persons. The largest percent of lower grade teachers (39.5%) think of themselves as competent to motivate other students to accept the students with disabilities. The biggest concordance of higher and lower grade teachers is about the statement that on physical education lessons there will be cooperation between the children with disabilities and the other children. For having successful cooperation, 34,6% of higher grade teachers and 27.9% of lower grade teachers consider themselves fully competent.

Table 2. The analysis of difference of higher and lower grade teachers in relation to certain statements

Statement	χ^2	df	p
Including students with physical disabilities in my PE class will help students without disabilities to learn to interact with persons with physical disabilities.	17.86	4	0.00
Including students with physical disabilities in my PE class will make teaching physical education more difficult.	43.99	4	0.00
Including students with physical disabilities in my PE class will encourage students without to help others.	5.782	4	0.20
Including students with physical disabilities in my PE class will make lesson planning and preparation much more difficult.	57.61	4	0.00
Including students with physical disabilities in my PE class will teach students greater tolerance.	20.143	4	0.00
Inclusion will have a positive effect on the development of personalities of students with physical disabilities (e.g. self esteem, feeling of belonging, etc.).	1.42	4	0.84
Students with physical disabilities will experience discrimination in my regular physical education classes.	3.054	4	0.94
Students with physical disabilities will slow down instruction and progress in my PE class.	1.425	4	0.83
Inclusion will cause my students to have better knowledge about persons with disabilities.	0.394	4	0.98
Inclusion will cause my students to have better knowledge about persons with disabilities.	0.723	4	0.94

On the basis of (χ^2) test and the level of statistical significance from p=0.00 we can state statistically significant difference in the attitudes of high and lower grade teachers in relation to competence to learn children without disabilities how to communicate with children with disabilities. Statistically significant difference between higher grade and lower grade teachers exists for other statement with a level of statistical significance p=0.00 in relation to competence that the presence of the students with disabilities does not make the physical education lesson more complicated. Statistically significant difference (p=0.00) exists between the attitudes of the higher grade and lower grade teachers about their competence that the inclusion of the students with disabilities will complicate lesson planning. There is also statistically significant difference between the attitudes of higher grade and lower grade teachers in relation to their competence to learn their students about tolerance during the lessons (p=0.00). There is no statistically significant difference between higher grade and lower grade teachers in their attitudes about competence on relation to the following six statements: the inclusion of the students with disabilities will teach other students how to help students with disabilities (p=0.20), the inclusion into regular physical education lessons will positively effect the development with the children with disabilities (p=0.84), with their competences they will prevent discrimination of the children with disabilities (p=0.94), the children with disabilities will not prevent discrimination of the children with disabilities (p=0.83), the students will acquire higher level of knowledge about the students with disabilities (p=0.98) and they will make good cooperation with the students with disabilities and other students (p=0.94).

DISCUSSION

The programme of physical education of primary school (2006) does not define special programme content for the children with disabilities. Only for the students with weaker health condition, smaller physical of functional abilities and bad posture and body deformities, corrective-pedagogical work is provided, which is realized at school or in cooperation with certain health institutions.

The teaching of physical education to children with disabilities has to be planned according to individual abilities of the children and organized so that it does not influence the development and strenghtening of the body. The gains represent basic part of this teaching method.

Some of the basic obstacles of inclusive education are: negative attitudes towards the students with disabilities, the laws of inclusive education have not been passed in many countries, and in those that they have, they are not applied, bad socio-economic factors, inedequate surroundings, inedequate language and comunication, resources, curriculum, organization and managment and inedequate data base (Brojcin and Glumbic, 2007).

In this research, concidering all ten statements for higher grade teachers there is no statement in which the attitude that they are not competent at all prevails. It is completely different for lower grade teachers and for the statement „*the inclusion of the students with special needs in my lessons will teach the students tolerance*“, they think that they are not competent at all. The same attitude is expressed for the statement „*the inclusion of the students with special needs in my lessons will complicate planning of the lessons*“, where 27.9% think that they are not competent at all and 37.75% that they are not competent. The largest numerical and percentage expression of insufficient competence is at lower grade teachers (49.3%), for the statement „*the inclusion of the students with special needs in my lessons will make my teaching more complicated*“. Even bigger numerical and percentage expression of insufficient competence is seen for the statement „*the inclusion of the students in my lessons will have positive effect on the development of the personality of the students with disabilities (for example self reliance, self respect, the feeling of belonging)*“: 49.4% of higher grade3 teachers and 54.3% of lower grade teachers. The largest numerical and percentage presence of the attitude about insufficient competence is seen for higher grade teachers (49.4%) and lower grade teachers (54.3%) in relation to the statement „*inclusionh of the students on my lessons will have positive effect to the development of the personality of the students with disabilities (for example self reliance, self respect, the feeling of belonging)*“. When you consider the attitude of higher grade teachers about competence it can be seen in the statement „*the inclusion of the students with special needs in my lessons will complicate my planning of the lesson*“ (49.7%), and for the lower grade teachers for the statement „*the inclusion of the students with disabilities in work in my lessons helps other students to learn how to comunicate with persons with disabilities*“ (71.7%). The largest number of teachers indicates that theyt are completely competent (34.6%) and that the inclusion of the students with disabilities will help other students to learn how to comunicate with the persons with disability. The most positive attitude for lower grade teachers about complete competence (37.7%), is met for the statement „*the inclusion of the students with disabilities in their lessons will encourage other students to learn how to help others*“.

CONCLUSION

The goal of this study was to research the attitudes of lower grade and higher grade teachers about inclusions of physical education teaching in primary school. With the sample of 60 higher grade teachers and 60 lower grade teachers in the region of Pomoravlje statistically significant differences in attitudes about their competence, in relation to certain statements were stated in four out of ten statements and that the inclusion of the students with disabilities in regular lessons will influence successful communication with other students, that inclusion of the students with disabilities will not make physical education lessons more complicated, that it will not negatively influence adequate planning and preparation of the lessons and that the inclusion of the students with disabilities will positively influence tolerance of other students. *The general statement indicates that all the participants of educational process should be actively involved in increasing of the quality of their competences for work with the students with special needs, which will produce more possitive attitudes towards inclusion.*

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THE EFFECTS OF COMPLEX TRAINING ON THE DEVELOPMENT OF MOTOR ABILITIES OF STUDENTS INVOLVED IN SCHOOL SPORT

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SUMMARY

The aim of this research was to determine the importance of complex, concentrated training at a volleyball camp for specific motor abilities, that is, how the designed training program will influence the increase in agility, explosive strength, specific coordination. The sample of respondents was composed of 20 female students from the elementary school "Radoje Domanović" from Belgrade, aged 11 to 14 years. The obtained results indicate that the effects of the experimental treatment on the tested variables **HEKSA$_{(sec)}$, 9-3-6-3-9$_{(sec.)}$, ESPRI15$_{(sec.)}$, EABAL$_{(m.)}$, KOOMPRE$_{(sec.)}$, KOOMPRO$_{(sec.)}$, REFL$_{(cm.)}$** (**ES** = 0.67^{LE}; 0.63^{ME}; 0.80^{LE}; 0.82^{LE}; 0.71^{LE}; 0.93^{LE}) were large, except for variable **9-3-6-3-9**, where the effects are approximately medium. The results of the research showed that the complex volleyball training at the sports camp could be an adequate model of extracurricular activities for the development of certain motor abilities.

Keywords: Sport camps, volleyball, explosive strength, agility, coordination.

INTRODUCTION

Physical education classes and good organization of the teaching process, especially in today's circumstances of modern information technologies and insufficient physical movement, are of crucial importance for the development of children during puberty. There is a wide-held opinion that mandatory physical education classes being realized in schools today are of special importance for the psycho-physical development of children and adolescents.

There is sufficient evidence that those who have developed a strong set of basic skills were probably more active during their childhood and adolescence, and thus developed the positive habit of taking part in physical activities their entire lives (Okely, Booth, & Patterson, 2001). Contrary to that, children who have not been able to obtain an adequate basis for movement competencies will very probably be excluded from taking part in organized sports activities and playing with their friends due to a lack of basic physical abilities and skills (Ignico, 1990).

School as an educational institution represents the most important environment for the promotion of physical activity among schoolchildren. Physical education and school sport, in addition to indirectly affecting the development of motor skills, primarily enable increased physical activities of children during physical education classes and extracurricular activities (Bailey, 2006; Sallis et al., 1997). It is highly recommended that school sport be a part of the educational process. We all agree on one point, and that is that school sport creates a versatile and educated personality (Savić, 2014). Furthermore, school sport represents an important part of society which indirectly influences the physical development of an individual, and directly contributes to the health, progress and well-being of an individual. In terms of their attitudes towards physical education and school sport, participants who actively took part in physical education classes and extracurricular activities (school sport) showed more favorable attitudes compared to physically inactive schoolchildren (Koca & Demirhan, 2004). The content of physical education programs and school sport competitions could significantly contribute to the overall volume of physical activity, and to most students having positive attitudes towards it (Trudeau & Shephard, 2005).

"School sport should not be studied in isolation from physical and health education, as it is theoretically and epistemologically connected to intellectual, moral, esthetic education. The pedagogical framework of school sport permeates the finest of education processes, which correspond to holistic orientations and the moralizing of personalities of athletes. Moral awareness and moral conscience are made richer through games, sports rules and moral principles personified in truth, justice and well-being and are proof of a saying we have in our parts: Protecting oneself from others (heroism) and keeping others safe from oneself (humanity)." (Savić, 2014).

"School sport will certainly develop further as part of its urban traditions, relying on educational institutions. Furthermore, school sport and physical education in our country will expose us to constant changes and reforms. The success of these changes and reforms will certainly also determine the future of school sport." (Savić, 2014: 78).

Students from the ages of 10 to 18 have positive attitudes towards physical education and school sport, which are more pronounced among boys than girls (Marković, Šekeljić, Višnjić, & Ilčev, 2013; Trudeau & Shephard, 2005; Van Wersch, Trew, & Turner, 1992). Based on other studies, we can note that elementary school students are more active, as well as that they display more positive attitudes towards physical education classes and school sport as compared to high school students (Radisavljević-Janić, Milanović, & Lazarević, 2012; Savić, Stojanović, Ranđelović, & Stojiljković, 2016). These data confirm the fact that positive habits regarding physical activity are developed during childhood and adolescence (Okely et al., 2001), which is why great attention should be paid to working with this specific population. High school students are faced with increased stress, which is caused by biological changes in puberty (Darst, Pangrazi, Sariscsany, & Brusseau, 2006; Sibley & Etnier, 2003). Today their schoolwork has increased in volume as a consequence of a more demanding curriculum, which is why they have less time to devote to physical activity and school sport (Protić & Prahović, 2007). Also, the cause of decreased interest might also lie in the exclusion of a larger number of students from school sports competitions, where privileges are mostly given to athletes (Shephard, Lavallée, & Larivière, 1978), as well as the fear that some students may have of participating in sport competitions (Thompson, Humbert, & Mirwald, 2003). The aforementioned implies that it is necessary to include students in the system of school competitions as early as possible, with the aim of promoting a healthy and motor "refined" population, and thus create positive habits regarding physical exercise. One of the possible solutions for promoting the physical improvement of children is the inclusion of optional extracurricular sport activities.

Volleyball as a sport abounds in various motor forms. In order for an elite volleyball player to perfectly perform each technical-tactical element, the appropriate optimal physical preparedness is necessary. An important segment of working with younger age categories is familiarity with the morphological, functional and psychological characteristics of children. One of the primary goals is for students to achieve proper knowledge, skills and habits regarding volleyball technique and to properly apply them in competitions (Ilić, 1983, 2008).

Volleyball differs from other sports in that it is characterized by rapid and unexpected changes in situations in the game. As such, it is classified at the very top of the most dynamic sports. One of the most significant problems of the game of volleyball is the realization of the end result, that is, observation of those elements of the game which are important for the successful realization of volleyball rallies (Ilić, 2008; Nešić, 2005).

In contemporary circumstances, volleyball rallies require the existence and systematized work of school sport groups and volleyball schools. They are specialized organized units for volleyball-sport development of children aged nine to eighteen (Nešić, 2005). Their special task is to use the educational and training process to contribute to the development of idiosyncratic characteristics of the students and develop them to a higher level, so that from the very beginning, after several years of high quality training, quality volleyball players might emerge (Nešić, 2005). A well-designed and pre-planned training program will ensure that most of the work is successfully completed "beforehand" (Nešić, Ilić, Majstorović, Grbić, & Osmanakač, 2013). The effects of well-organized combined training are primarily reflected in a positive influence on the growth and development of a young body on the one hand, and increase in motor abilities on the other.

Today sport is not only the reason for residing abroad, but is often the primary motivation for travelling to certain tourist destinations. This has led to the development of a special kind of tourism: **sports-recreational tourism**. Attending sports camps as a form of travel and staying at a certain destination have a significant educational importance for students (Savić, 2014). Based on the aforementioned, it is clear that camps are an ideal solution to the implementation of a concentrated complex training program, which will influence the development of certain motor skills of girls during adolescence. The organization and realization of sports camps requires professionalism and the participation of all the members. The camp content is previously determined by a plan and program which depends on the sport of choice, in this case, volleyball content.

With all this in mind, the basic aim of this study is the overview and analysis of the influence of a complex volleyball training program on changes in certain general and specific motor skills of female students, with the aim of indicating the importance of physical activity for the increasing problem of less and less time being spent on physical activities, and instead being spent in front of computer screens or in sedentary activities among children and the young alike. School as an educational institution and sport clubs are charged with realizing extracurricular activities, and can exert great power and influence on solving this problem, which is why it is necessary to stress the importance of sports camps as adequate models for the development of individual motor skills.

THE METHOD

The sample of participants

The research was carried out on a sample of 20 girls (164.10±5.36cm), aged between 11 and 14. The girls exercised according to a special training program for a period of 10 days. The experimental program and measurement procedures included only completely healthy girls. The female participants were familiar with the basic methods and aims of the experiment. Agreement for participation in the training and measuring was obtained prior to their departure to the volleyball camp. The research was conducted in accordance with the Helsinki Declaration. Each female participant could at any time not follow through with the planned activities, due to possible emerging problems in the realization of the training and measuring procedure. All of the female participants successfully completed the experimental program and the initial and final measurement procedure.

Procedure

The basic characteristics of the plan and program designed for extracurricular activities (volleyball camp) prepared for and executed by the experimental group included the following training schedule: the female volleyball players trained for a total of 10 days (twice daily, in the morning and afternoon).

The program contained elements of the training process for developing basic motor skills (the application of natural forms of movement), as well as elements of volleyball technique and elements of individual and group tactics. With the aim of studying the effects of complex training on the motor skills of the girls, it was necessary to develop a detailed plan for each training session, as part of an appropriate training program. The training sessions were divided into two separate units during a single day, for a duration of ten consecutive days (20 training sessions), 90 minutes per session. We made sure that the time intervals between two training sessions were no less than six hours, to allow adequate recovery. The morning training sessions were focused on developing basic abilities (conditioning training), while the focus during the afternoon training sessions was on the development of technical-technical elements of the volleyball game. It is important to mention that the method of undulated loading was included within the conditioning training (cf. Bompa & Buzzichelli, 2018).

The initial measurements were taken two days prior to the departure for the volleyball camp, and the final two days following the return from camp.

The sample of applied variables for the evaluation of basic motor skills of the female students consisted of the following measuring instruments:

- Hexagon agility test
- 9-6-3-6-9 agility test
- 15m sprint (ЕСПРИ15)
- the Abalakov test
- Net coordination test (КООМРЕ)
- Spatial coordination test (КООПРО)
- Falling baton test (РЕФЛ)

Statistical analysis

Due to the nature of the experiment, it was necessary for all the data for the experimental group to be collected during the initial and final measurement procedure.

To analyze the basic statistical data and result distribution at the initial and final measurement procedure, descriptive statistical procedures were used, and the following parameters calculated:

- Mean – means;
- Min. – minimal achieved result;
- Max. – maximal achieved result;
- Std.Dev. – standard deviation;
- Skew. – skewness;
- Kurt. – kurtosis;
- Kolmogorov-Smirnov test of probability distributions (K-S).

To test the differences between the results for the dependent variables between the initial and final measurement procedures at the multivariate and univariate level, the analysis of variance for repeated measures (MANOVA and ANOVA – repeated measures) was used, while significance was determined at the p ≤ 0 .05 level.

The effect size was calculated using partial eta squared (η^2p) (cf. Keppel, 1991). The values of the effect size (ES) were classified according to (Ferguson, 2009) in the following way: no effect if $0 \leq \eta^2p < 0.05$; small effect (SE) if $0.05 \leq \eta^2p < 0.26$; medium effect (ME) if $0.26 \leq \eta^2p < 0.64$; and large effect (LE) if $\eta^2p \geq 0.64$.

Within the aforementioned analyses the following parameters were calculated:

- Wilks' lambda – the value of the coefficient of Wilks' test for means equality;
- F – the value of the coefficient of the F-test for the significance of Wilks' lambda;
- Effect df; Error df – degrees of freedom;
- Q – significance coefficient for the differences between two samples.

The data were processed using the statistical package STATISTICA 7.0 for Windows (StatSoft, Inc., Tulsa).

RESULTS

Table 1. Descriptive parameters of motor skills for the experimental group at the initial and final measurement procedure

Variable	N	Mean	Min.	Max.	Std.Dev.	Skew.	Kurt.	K-S (d)
TVIS	20	164.10	153.00	172.00	5.36	3.27	-0.55	-0.66
TMAS	20	57.75	42.00	77.00	9.12	15.79	0.18	-0.53
HEKSA I.	20	18.75	14.79	22.18	2.26	-0.04	-0.82	0.13
9-3-6-3-9 I.	20	10.06	9.19	11.18	0.56	0.46	-0.57	0.12
ESPRI15 I.	20	3.27	2.82	3.71	0.22	0.03	0.55	0.17
EABAL I.	20	2.40	2.27	2.53	0.07	-0.12	-0.88	0.16
KOOMRE I.	20	6.84	5.63	8.06	0.65	-0.29	-0.73	0.15
KOOPRO I.	20	6.26	5.68	6.97	0.43	0.06	-1.62	0.17
REFL I	20	16.55	10.00	24.00	2.95	0.27	1.65	0.11
TVIS	20	164.10	153.00	172.00	5.36	3.27	-0.55	-0.66
TMAS	20	57.75	42.00	77.00	9.12	15.79	0.18	-0.53
HEKSA F	20	17.92	14.10	21.77	2.18	0.05	-0.76	0.10
9-3-6-3-9 F	20	9.73	8.94	10.66	0.50	0.29	-0.57	0.10
ESPRI15 F	20	3.12	2.77	3.48	0.18	-0.05	-0.16	0.09
EABAL F	20	2.42	2.30	2.57	0.07	0.15	-0.67	0.11
KOOMRE F	20	6.42	5.04	7.41	0.72	-0.58	-0.87	0.20
KOOPRO F	20	6.05	5.40	6.81	0.45	-0.01	-1.56	0.19
REFL F	20	13.15	8.00	20.00	3.00	0.31	-0.04	0.13

Legend: N – number of participants; **Mean -** means; **Min –** minimal value of the results; **Max –** maximal value of the results; **Std.Dev. –** standard deviation; **Skew. -** skewness; **Kurt. –** kurtosis; **K-S (d) –** significance of the Kolmogorov-Smirnov coefficient.

Table 1. presents the basic descriptive parameters of the variables of anthropometric characteristics and motor skills at the initial measurement procedure for the experimental group. For each variable the following was calculated: the means (Mean), the value of the minimal (Min.) and maximal (Max.) achieved results, standard deviation (Std.Dev.), skewness (Skew.) and kurtosis (Kurt.), as well as the values of the Kolmogorov-Smirnov test (K-S(d)). The indicators of skewness (Skew.) of the anthropometric characteristics and motor skills of the female participants are located within the limits of normal distribution, with a positive and asymmetry towards weaker results for the variables **TMAS, 9-3-6-3-9** and **REFL,** while a symmetric distribution of the results was noted for the variables **HEKSA, ESPRI15** and **KOOMPRO.** A negative asymmetry, a shift in the curve to the right in the direction of more favorable results, was noted for the variables **TVIS, EABAL** and **KOOMPRE.**

The values of statistical parameters of kurtosis (Kurt.) of the results of anthropometric characteristics and motor skills of the female participants describe a light platykurtic distribution for all the tested variables, except for the variables **ESPRI15** and **REFL**, where the obtained results indicate a light leptokurtic distribution.

Table 1. presents the basic descriptive parameters of the variables of anthropometric characteristics and motor skills at the final measurement procedure for the experimental

group. For each variable the following was calculated: the means (Mean), the value of the minimal (Min.) and maximal (Max.) achieved results, standard deviation (Std.Dev.), skewness (Skew.) and kurtosis (Kurt.), as well as the values of the Kolmogorov-Smirnov test (K-S(d)). The indicators of skewness (Skew.) of the anthropometric characteristics and motor skills of the female participants are located within the limits of normal distribution, with a positive and asymmetry towards weaker results for the variables **TMAS, 9-3-6-3-9, EABAL** and **REFL,** while a symmetric distribution of the results was noted for the variables **HEKSA, ESPRI15** and **KOOMPRO**. A negative asymmetry, a shift in the curve to the right in the direction of more favorable results, was noted for the variables **TVIS** and **KOOMPRE**.

The values for **REFL** were determined to be near the "theoretical" mesokurtic distribution. The results of the Kolmogorov-Smirnov test K-S (d) were below the borderline value with a value of max.d=0.23, for a sample of 20 female participants, at the level of statistical significance of p>0.20 (Facchinetti, 2009) and thus confirm the normal distribution of the results for all the variables.

Table 2. The multivariate differences between the initial and final measurement procedure of the motor skills of the experimental group

Wilks Lambda	F	Effect - df	Error - df	Q
0.027	66.66	7	13	**0.000***

Legend: Wilks lambda – the value of Wilk's test of mean equality; **F** – the value of the F-test coefficient for the significance of Wilk's lambda; **Effect df; Error df** – degrees of freedom; **Q** – coefficient of the significance of the difference in means.

By analyzing the results of the multivariate analysis of variance of the differences between the initial and final measurement procedures for the experimental group of girls (**Table 2.**), at the multivariate level we find statistically significant differences at the final measurement compared to the initial one with a level of significance of **p=0.000**, which fulfills the set theoretical requirement **(p ≤ .05).**

Table 3. The univariate differences between the initial and final measurement procedure of the motor skills of the experimental group

Variable	Fi-In	%Δ	F (1; 18)	p	ES
HEKSA	-0.83	-4.4	37.92	**0.000***	0.67[LE]
9-3-6-3-9	-0.33	-3.3	33.02	**0.000***	0.63[ME]
ESPRI15	-0.15	-4.6	74.91	**0.000***	0.80[LE]
EABAL	0.02	0.8	88.45	**0.000***	0.82[LE]
KOOMRE	-0.42	-6.1	45.65	**0.000***	0.71[LE]
KOOPRO	-0.21	-3.4	244.77	**0.000***	0.93[LE]
REFL	-3.40	-20.5	86.47	**0.000***	0.82[LE]

Legend: Fi-In – the difference between the initial and final measurement procedure; **%Δ** – the difference between the initial and final measurement procedure in percentages; * - statistically significant differences; **ES** – effect size; [NE] – no effect; [SE] – small effect; [ME] – medium effect; [LE] – large effect.

By analyzing the results of the univariate analysis of the differences between the initial and final measurement procedure for the experimental group of girls (**Table 3.**), it can be noted that statistically significant better results were recorded for all the variables of motor skills at the final measurement compared to the initial one. The differences between the measurement procedures are manifested with a great effect for all the variables, except for the variable **9-3-6-3-9** for which the differences are within the mean values of the effects, which with the degrees of freedom provides a level of significance of **p=0.000**, and fulfills the theoretical requirement **(p ≤ .05).**

DISCUSSION

Based on the findings of a study carried out in collaboration with the Ministry of Education of the Republic of Serbia, the Ministry of Youth and Sport and the National institute for sport on the physical abilities of elementary school children, boys showed a 6% and girls 12% decline on certain motor tests when compared to their previously recorded results. At the same time, it was determined that the results recorded for the children from Serbia were mostly below the average recorded for the children from the EU (Kraljević, Gadžić, & Vučković, 2013).

There are several factors which are positively connected to the physical activity of young people, including self-efficiency and the ability to overcome barriers for inclusion in physical activity (Health & Services, 1996; Trost et al., 1997), perceptions of physical or sports competencies (Health & Services, 1996; Sallis, Prochaska, & Taylor, 2000) (Health & Services, 1996; Stuckyropp & DiLorenzo, 1993), and parent, family or peer support (Health & Services, 1996; Sallis et al., 2000), all of which can have positive effects on physical exercise. An additional determinant of physical activity among children and adolescents might also be the level of ability for performing movement, which is the basis of skills which will later be used in physical activity for performing various movements required for physical activity during adulthood (Okely et al., 2001; Payne & Isaacs, 2017). Movement skills are monitored at a moderate level during childhood (Branta, Haubenstricker, & Seefeldt, 1984; Burton & Miller, 1998; R M Malina, 1990; Robert M Malina, 1996), so that the quality of the developed motor skills at a younger age could be used with more success to predict the level of physical activity during the course of one's life. Children and adolescents with better motor skills will find it more easy to opt for physical activity, compared to their peers with weaker abilities and motor skills (Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006). Adolescents with weaker motor skills will later more frequently select a sedentary lifestyle so as to avoid any difficultly in performing movements (Petrolini, Iughetti, & Bernasconi, 1995). Researchers have indicated significant positive correlations between motor skills and visual-motor coordination (Petrolini et al., 1995) and the physical activity of adolescents. Thus, adolescents included in organized forms of extracurricular physical activity had a more positively pronounced motor fitness level, measured by the depth jump test, compared to children who had not been included in any model of organized extracurricular physical activities (Koutedakis & Bouziotas, 2003). Adolescents with lower levels of self-determination for physical activity have poorer coordination and reported lower levels of physical activity than their peers (Hay, 1992; Hay & Missiuna, 1998).

The recommendations of certain authors stress the importance of everyday physical activity and encourage young people (adolescents) to be physically active anywhere from between 30 to 60min (Aaron et al., 1993; Andersen, Crespo, Bartlett, Cheskin, & Pratt, 1998; Butcher, 1983) to several hours a day (Andersen et al., 1998). Considering that maintaining moderate to intense physical activity is connected with specific health advantages, this pattern of activity is also recommended (Andersen et al., 1998; Butcher, 1983). Other recommendations included activities for promoting strength, flexibility, bone health (Aaron et al., 1993) and avoiding longer periods of inactivity (Andersen et al., 1998). Approximately one fourth of female adolescents reported 20min of moderate to intense physical activity three times a week (Biddle & Goudas, 1996). Of the time prescribed for the realization of physical education classes as part of a national curriculum of 135min a week, this does not satisfy the recommended optimal time for performing physical activity, and it is very important for physical education teachers to stimulate and focus students to take part in sports activities or any kind of physical activity outside of school hours (Radisavljević-Janić et al., 2012). Even though there is a possibility that adolescents will develop fundamental motor skills based on their innate potential, it is more probable that the rate of their development will be greater with an adequate exercise program, instructions and feedback (Bar-Or & Baranowski, 1994; Baranowski, Anderson, & Carmack, 1998).

It has previously been cited that insufficient physical activity is a great problem for adolescents, so that it is necessary to find adequate models for the realization of extracurricular activities in order to include as many students of this age as possible, and one of them are certainly sport camps. Sport camps provide conditions for the realization of the training process with a focused training program. The frequency of training sessions is high, and there is a possibility of distributing 20 separate training units within 10 days, which might significantly affect the development of motor skills.

When it comes to tests of explosive power **(ESPRI15M** and **EABAL)**, we can conclude significant positive effects of the training process were noted **(ES = .80; .82)**. These obtained results can be justified by the conclusion that, even though in the methodology of training volleyball technique there are not many specific exercises for the development of the tested parameters of explosive power, which are based on the maximal inclusion of the vertical component of the explosive power of the leg extensors – which would mean that there are not many vertical jumps – standing or running (Nešić et al., 2013), complex power training, which in its structure consists of specific exercises for the development of this ability, significantly influences its development. On the other hand, when speaking of specific motor skills, a significant improvement was noted at the final measurement, which could certainly be ascribed to the influence of complex training, which in its structure, in addition to exercises for the development of basic motor skills, contains various elements for the development of basic motor skills, as well as various elements of the development of specific volleyball movement structures (Bajrić, Šmigalović, Bašinac, & Bajrić, 2012; Korjenić, Jelčić, Basinac, & Begović, 2012; Šmigalović, Bajrić, & Lolić, 2012). However, we should be careful when making conclusions. Even though according to Keppel, Saufley, & Tokunaga (1992) the extent of the effects after the experimental treatment is great, except for variable 9-3-6-3-9, where we note an average value of the effects, it is important to mentioned that the sample of girls included in the experimental program had not previously been included in any form of physical activity, except for regular physical education and extracurricular activities as part of school sport, whose extent and intensity did not satisfy the basic principles of motor skills training (Sheppard & Triplett, 2016). Based on the results of previous studies (Jurg, Kremers, Candel, Van der Wal, & Meij, 2006; Koutedakis & Bouziotas, 2003; Pate et al., 2006; Sallis et al., 1997), which dealt with the issues of character, quality and intensification of physical education classes, it was indicated that the current physical education program is insufficiently oriented on systematic and varied physical exercise and that it lacks a suitable volume and intensity which would cause adequate stimuli with the aim of developing motor abilities of the students. Also, other authors (Đorđić & Matić, 2008; Pedersen & Seidman, 2004) point out the negative trend in the physical activity of students, especially in the population of girls who are significantly less active, especially during adolescence, which only confirms the previous conclusion. In addition, it is important to mention that the noted improvement in motor skills did not just "emerge" due to the influence of the experimental treatment among the girls, but can also in part be ascribed to biological factors as well, that is, the "sensible" (critical) phases in development during adolescence, which include accelerated occurrences in growth and development, especially regarding certain motor skills. Accelerated occurrences are characteristic of the "sensible" periods, during which specific influences on the human body cause increased reactions, especially during "critical" periods, which are a part of the sensible period during which stimulations must occur if we wish to achieve the desired developmental effects (Koprivica, 1996; Viru et al., 1999). Certain authors cite that girls mature earlier and that the sensible periods of development of certain motor skills occur earlier than they do among boys, since girls enter puberty sooner (Malina, 1990; Malina, 2004). Malina (2004) considers that the most suitable age for the development of frequency of movement is 11 to 13 among the girls, while **agility** is believed to develop dynamically during the ages from 7 to 11/12 until the age of 13 among girls, which leads to a gradual decrease in the development of this ability. Also, Koprivica, (1996) points out that the sensible period of development of **explosive power** begins around the age of 8, and the critical phase between the ages of 7 to 17 with a special emphasis on ages 8-9, 10-11, 13-14, and especially 14-15. It is likely due to this reason that the effects of the experimental program were extensive, as was the response to the high training stimulus. We can assume that the results would not have been this pronounced had the girls been subjected to an adequate training process prior to this experimental treatment.

CONCLUSION

The significance of this research lies in pointing out the importance of a well-planned complex training program which, irrespective of the end result of the match, is always a high-quality way of spending time, while the means and effort invested into the training by the teacher, coach and the children, but also the parents, or guardians, are an investment in the health of those who will inherit the world. Physical development and the improvement of motor skills are significant components which can be influenced by successfully planned physical exercise, irrespective of certain limitations which can be found in each individual imposed by hereditary factors.

The aim of this research was to determine the effects of a ten-day training program carried out in a sport camp on the development of motor skills of female adolescents who recreationally took part in volleyball practice as part of their school sport activities. This enabled the further planning of training and increase in physical ability to a higher level. For this sample of 20 female participants, and following the completed analyses of the obtained research results, we can note a statistically significant increase in motor skills. It is important to stress that the lifestyle of children and adolescents today is mostly secondary to sitting in school, in IT workshops, in music schools, foreign language schools. Thus, even after class children remain in a seated position with minimal movement. This kind of lifestyle, and a poor diet based on fast food, lead to the abilities of children – students not developing as quickly, and to their lagging behind in physical development. Thus, the inclusion of students in a selected sports activity is of great importance, and imposes the need for organized extracurricular activities, in this case sport camps, as adequate models for the development of motor skills of students participating in school sport.

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DIFFERENCES IN BILATERAL COORDINATION STATUS BETWEEN MALE AND FEMALE STUDENTS WITH INTELLECTUAL DISABILITIES

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SUMMARY

The aim of this study was to examine the bilateral coordination status of the young people with mild intellectual disabilities (ID), and to determine if there are any differences between genders. Subjects who participated in this study were 28 adolescents (16 males and 12 females) age 15 to 19 years (17.15±1.24 years) with mild ID attending special school "October 14th " in Nis. Bilateral coordination was tested by seven items of subtest Bilateral coordination up to Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT-2). Results showed low to the extremely low level of examined motor ability, according to descriptive criteria. There were no statistically significant differences between genders (t (26) = 1.099, p=.282) in a status of bilateral coordination. Obtained results indicate the need to improve the bilateral coordination in this population, as essential motor skill, through various exercise forms.

Keywords: BOT-2, coordination, special school.

INTRODUCTION

Motor abilities are human skills that express physical preparedness for work and creative expression of own personality. Motor abilities are involved in solving the motor tasks and cause the successful movement regardless of whether they were acquired by training or not. They are including strength, speed, endurance, coordination, flexibility, balance and accuracy. Coordination is a complex motor ability, which is characterized by compliance of time, space and energy parameters of movement and motion. Coordination consists of: dexterity, agility, balance and precision, abilities that largely depend on the central nervous system. A sensitive period for the development of these motor abilities is in the period from 7 to 12 years in children with typical development (Stojiljkovic, 2003).

The Bruininks-Oseretsky Test of Motor Proficiency (Bruininks, 1978) is a standardized, norm-referenced measure used by physical therapists and occupational therapists in a clinic and school practice settings. This test recently was revised and published as the Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT-2) (Bruininks & Bruininks, 2005). The BOT-2 is an individually administered measure of fine and gross motor skills of children and youth, 4 through 21 years of age. It is intended for use by practitioners and researchers as a discriminative and evaluative measure to characterize motor performance, specifically in the areas of fine manual control, manual coordination, body coordination, and strength and agility **(**Deitz, Katrin & Kopp, 2007). Body coordination is a composite consisting of two subtests: Bilateral coordination and Balance. The tasks require body control and sequential and simultaneous coordination of the upper and lower limbs. The BOT-2 is often used to provide support for diagnoses that involve motor control deficits. It can identify motor performance deficits in individuals with developmental coordination disorders (DCD), mild to moderate intellectual disabilities (ID), or high-functioning autism/Asperger's Disorder (Bruininks & Bruininks, 2005).

Intellectual disability is characterized by impaired intellectual and adaptive functioning and is defined on the basis of three criteria: sub-average intellectual functioning, significant limitations in adaptive life skills, and manifestation of these two deficits before the age of 18. Approximately 3% of the population meets these criteria (American Association of Intellectual and Developmental Disabilities, AAIDD, 2007**).**

Coordination is necessary for everyday activities. Its connection with executive functions (working memory, inhibition, and switching) was investigated and specific associations were confirmed (Haga, 2008; Michael, 2012; Rigoli, Piek, Kane, & Oosterlaan, 2012). Although individuals with a lower measured IQ more often showed poorer motor performance than those with a higher measured IQ, motor skill at all levels of proficiency was seen in all IQ categories (Smits-Engelsman, Hill, 2012).

There is a growing number of studies examining the motor skills of children and young people with disabilities in intellectual functioning (Van de Vliet, Rintala, Fröjd, Verellen, Van Houtte, et al., 2006; Einarsson, Arngrimsson, Vanlandewijck, & Daly 2011; Jankovic-Szymanska, Mikolajczyk, & Wojtanowski, 2012; Blomqvist, Olsson, Wallin, Wester, & Rehn, 2012), but a small number of them deal with coordination in particular (Michael, 2012; Rigoli et al., 2012). The aim of the present study is to assess the status of bilateral coordination (as one part of body coordination composite) in high school students with mild ID, and to determine if there are any differences between genders.

METHODS

Subjects

The participants comprised a total of 28 high school students- 16 male and 12 female (mean age 17.15±1.24 years, height 169.50±12.13 cm, weight 67.21±15.06 kg, BMI 23.44±4.76 kg/m^2) that attend special school "October 14th" in the city of Nis. All participants, as well as their parents or guardians, gave written consent before measuring. In order to balance sample by the level of intellectual disability, the school psychologist recommended a list of students. Measured subjects have a mild intellectual disability (IQ between 50 and 75). Total mean scores for the students' ages, mass, high and body mass index are described in Tables 1. and 2. for the female and male subjects respectively.

Table 1. Descriptive statistic for female students' general data

	N	Min	Max	Mean	SD
Age (years)	12	15.35	18.39	16.84	1.014
Mass (kg)	12	39.10	78.60	61.16	14.05
High (cm)	12	149.00	173.50	159.67	7.55
BMI (kg/m^2)	12	17.50	34.00	24.08	5.79

Table 2. Descriptive statistic for male students' general data

	N	Min	Max	Mean	SD
Age (years)	16	15.12	19.66	17.39	1.38
Mass (kg)	16	35.30	98.60	71.74	14.58
High (cm)	16	154.00	198.00	176.88	9.37
BMI (kg/m^2)	16	16.90	30.40	22.96	3.95

The tasks done for Bilateral coordination subtest (BOT-2) were: touching nose with index fingers-eyes closed, jumping jacks, jumping in place-same side synchronized, jumping in place-opposite side synchronized, pivoting thumbs and index fingers, tapping feet and fingers-same side synchronized and tapping feet and fingers-opposite side synchronized. Measuring was conducted in accordance with the standards of the 2008 Helsinki Declaration on the Ethical Principles for Medical Research Involving Human Subjects (**WMA, 2011**) in sports hall of special school "October 14th" in Nis.

Procedure

Bilateral coordination was determined by seven tasks of Bruininks-Osertsky Test of Motor Proficiency, Second Edition (BOT-2) subtest Bilateral coordination. This subtest measures the motor skills involved in playing sports and many recreational games. The subtest total point score is obtained by adding the point scores of the individual item that make up subtest. Total point scores were converted in to scale scores, which are gender and age specific norms. BOT-2 gives the opportunity to convert the scale scores into descriptive criteria, and the total point scores to the age equivalent.

Statistical analysis

Obtained data were analyzed using statistical package SPSS 20.0. Arithmetic means (Mean) and standard deviation (SD) were calculated for all variables obtained in this study. Due to the small sample size, the Shapiro-Wilk Test (with the significance level set at p>.05) was used to assess the data normality in distribution. To determine differences between groups t-test for independent samples was used (Pallant, 2005). The significant level up to .05 (p<.05) is accepted as statistical significance for result differences between two groups.

RESULTS

The results of the descriptive statistical analysis for the subtest Bilateral coordination scores are presented in Table 3. There are results for the normal distribution (Shapiro-Wilk test) for female and male subjects separately, too.

Table 3. Descriptive statistics for the subtest of Bilateral coordination standardized data (BOT-2)

Variable	Gender	N	Min	Max	Mean	SD	Shapiro-Wilk (p)
BLTC	**Girls**	12	1.00	8.00	5.33	2.15	.407
	Boys	16	2.00	17.00	6.94	4.68	.002
	The whole sample	28	1.00	17.00	6.25	3.84	

Legend: BLCT-bilateral coordination total point score; p>.05.

Table 4. The differences in the results for Bilateral coordination subtest between male and female subjects (independent t-test)

Variable	t	df	p
BLTC	1.099	26	.282

The results for Shapiro-Wilk test indicated that the variable BLTC (bilateral coordination) has normal distribution for the girls (p>.05), but not for boys (p<.05).

Table 4. presents the results of the t-test for independent samples. The results indicate that are no statistically significant differences between males and females in variable BLTC, at the significant level p<.05 (Mean=6.94, SD=4.68 in male subjects; Mean=5.33, SD=2.15 in female subjects; t (26)= 1.099, p=.282).

DISCUSSION

The purpose of this study was to determine the status of bilateral coordination and find is there any differences between boys and girls with mild intellectual disabilities. The results showed that there are no statistically significant differences between genders in assessed motor ability. Means and standard deviations of BOT-2 subtests scale scores are statistically significant different between individuals with mild to moderate intellectual disabilities and the nonclinical reference group. According to Bruininks & Bruininks (2005) study subtest Bilateral coordination has an average standard score value 6.3 for mean and 2.9 for standard deviation in the intellectually disabled sample age 5 to 21 years. This is result similar to obtained in the present study (Mean=6.25, SD=3.84).

Considering this fact, the results were compared with the standardized values for the age and gender adequate ones. The obtained results show that the bilateral coordination status of many subjects is below average or very low according to descriptive criteria. According to the criteria of calendar age equivalent, the results are also extremely worrying- they fit to values for children aged five to seven years.

BOT-2 estimates body coordination composite using subtests bilateral coordination and balance. In the previous study Stanković, Aleksandrović, & Aleksić-Veljković (2013), the balance status of young people with mild intellectual disability is established as extremely worrying, as well as that there is no statistically significant difference between the sexes.

It is not easy to positively affect the complex coordination capacity since it is under the direct influence of the central nervous system. However, today more and more researches explore the effects of specific intervention programs on motor skills, as well as coordination of children and young people with mild to moderate intellectual disabilities (Wuang, Ho, & Su, 2013; Top, 2015; Stojanovic, 2018).

One of the most established findings in the motor control literature is that individuals with intellectual disabilities demonstrate deficiencies in almost all aspects of motor proficiency (Bruininks, 1974; Bruininks & Chvat, 1990; Newell, 1997). These individuals are less proficient than their normally developing peers at initiating and executing movements, exhibit poor performance on tasks requiring upper-limb speed and accuracy, have longer reaction times, and exhibit greater variability in response speed when choices are provided or when the demand for accuracy is high (Bruininks & Bruininks, 2005).

CONCLUSION

Based on the obtained results, it can be concluded that the status of bilateral coordination in young people with intellectual disability is low and extremely low. Consequently, it is necessary to explore the possibilities of applying for adequate training programs in order to improve coordination. The motor coordination status should be assessed already in children with mild to moderate intellectual disabilities with starting school because timely action guarantees better results.

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EFFECTS OF PHYSICAL EXERCISE WITH PRESCHOOL CHILDREN

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SUMMARY

The main objective of the paper was determining global quantitative changes of morphological and motor characteristics of preschool children under the influence of a six-month programmed physical exercise within the work of sports school. The study was conducted on a sample of 103 respondents of masculine gender, between the ages of 4 to 6 years old. In order to determine global quantitative changes, canonical discriminant analysis in the manifest space was applied, which determined statistically significant difference at the level of significance p = .000. The test for assessment of static strength of arms and shoulder area (MSSIZD .823) is the most responsible for the changes achieved, followed by the test for assessment of the upper extremities alternative movements (MTAPRU .334) from the space of mobility, and foot length (ADUŽST .258) from the space of morphology. The proposed supplementary physical exercise programme should be incorporated while work in preschool institutions.

Key words: physical exercise, global quantitative changes, canonical discriminant analysis, pre-schoolers.

INTRODUCTION

Identification and determination of quantitative statistically significant changes in morphological and motor characteristics of preschool children under the influence of certain physical exercise programmes has theoretical and practical value. Morphological and motor status of preschool population, especially the possibility of its transformation, was studied by a relatively small number of scientists. Given that playing is inherent to children, they unconsciously entail a variety of skills through it in an interesting way, the skills that they will further improve through physical activity. According to the theory on transformation processes, the effects of various programme contents differ from each other. Variability of the programmed contents effects depends on structuring the programme activities and on the specificity of anthropological dimensions on which the positive effect is desired.

On the one hand, studies on gender differences in morphological characteristics of preschool children show that the difference is almost non-existent (Katić et al, 1999; Vidaković and Korica, 2007). On the other hand, Bala (2007) and Rodić (2010) find differences in the space of motor skills in relation to the gender, but the recommendation is that physical exercise programmes are organized jointly for boys and girls. Gender differences in relation to motor skills are increased with age (Telford, Salmon, Timperio, & Crawford (2005). There is significant differentiation of motor skills in motor behaviour of children as early as from the age of three, up to the age of seven (Strel, Šturm, Pistotnik and Lenarčič, 1981; Rajtmajer and Proje, 1990; Planinšec, 1995, Rajtm), but also they talk about incomplete differentiation of motor skills in this age of children (Sabo, 2002).

Everyday participation in various forms of physical activity has a positive effect on growth and development of the organism (Hennessy et al., 2010; Eathern, Morgan, & Lubans, 2013). Alarming number of students declares that they spend their free time at the computer and by the television which puts them in a situation of risk factors action on health (Đokić, 2014). Obese and excessively obese children of both genders showed significantly lower scores in coordination comparing to children with normal body weight (Lopes, Stodden, Bianchi, Maia, & Rodrigues (2012). Obese children are less physically active than children with normal body weight and this poses a risk for further disease progression (Trost, Sirard, Dowda, Pfeiffer, & Pate, 2003; Planinšec and Matejek, 2004).

Numerous research address studying correlation of morphological characteristics and motor skills of preschoolers (Bala, Jakšić and Katić, 2009; Bala, & Katić, 2009; Veselinović, Milenković and Jorgić, 2009; Obradović et al. 2011; Martinović, Pelemiš, Branković and Živanović, 2013; Lepeš, Halaši, Mandarić, & Tanović, 2014).

The main objective of the research was to determine quantitative and qualitative changes of morphological characteristics and motor skills in male preschool children (4 to 6 years old) from the territory of the city of Banja Luka caused by the effects of a six-month physical exercise programme within the sports school.

WORK METHOD

The participants' sample

The participants' sample for the research purposes was derived from the population of preschool children from preschool institutions 'Zvjezdica' from the territory of the city of Banja Luka. The research included a total of 103 male participants - children aged 4-6 years (70 participants - 4 years, 12 participants - 5 years, 21 participants - 6 years). In order for the children to be the participants' sample in this research, consent was requested from their parents, signed personally by the parents of the participating children with their signatures. All the children were physically and mentally healthy and without any mental or physical aberrations.

The variables sample

The measuring instruments' sample for morphological characteristics assessment consisted of the following: body height (AVISTJ), foot length (ADUŽST), shoulder width (AŠIRRA), body weight (ATEŽTJ), average circumference of the chest (ASROGK), circumference of the upper leg (AOBNAT), body mass index (BMINDX) and fat percentage (POSMAS). Gathering of anthropometric measurements was performed according to the International Biological Program instructions (IBP).

The measuring instruments' sample for motor skills assessment consisted of the following: hand tapping (MTAPRU), long jump (MFESDM), Flamingo - balance test (FLAMIN), retraction in sitting position (MFDOSU) and pull up (chin-up) endurance (MSSIZD).Standardised mobility tests with good metric characteristics (validity, reliability, representativeness and homogeneity) were used for assessment of motor skills in preschool children, according to the reduced theoretical model of Kurelić et al. (1975) and Gredelj et al. (1975).

Description of the experiment

Programmed guided activities during six months, 48 sessions of physical exercise were completed (2 times a week), and the duration of one session of physical exercise was 35 to 40 minutes. Detailed description of programmed contents is an integral part of the Annual work plan of Sports School 'Zvjezdica' Banja Luka.

Statistical analyses

In order to determine the level of global quantitative changes in the tests of morphological characteristics and motor skills of preschool children caused under the influence of a six-month programmed physical exercise within the sports school, canonical discriminant analysis was applied at the multivariate level. The criterion for discriminating power of applied morphological and motor variables was the so-called Wilks' lambda. Determining the statistical significance of each discriminatory variable was performed based on Bartlet's chi-square test. Significant discriminatory variables were used to interpret the results, and they explain specific percentage of common variance.

RESULTS AND DISCUSSION

Prior to analysing the discriminant analysis results, the Box test (Table 1) found that there are statistically significant differences in the covariances of the analysed matrices (p= 0.000), which justifies application of canonical discriminant analysis.

Table 1. The Box test

Box's M		1901.045
F	Approx.	19.501
	df1	91
	df2	130429,238
	Sig.	**.000**

Key: df-degrees of freedom

Based on the results shown in Table 2, the differences between initial and final measurement in quantitative changes at the global level of the physical exercise programme in the space of morphological and motor skills were analysed. Observing the results' values shown in Table 2, it is evident that a statistically significant discriminant function (Canonical Correlation .808) is isolated, showing the correlation of a set of data based on which discriminant analysis of the obtained results was performed. It is evident from the table that there is a high correlation of the isolated discriminant function and that the variables having the largest and most significant contribution to the discriminant function, i.e. differentiation between the initial and final measurement results, will appear in further analysis. Based on the results of the discriminant analysis (Table 2), it is evident that there is a statistically significant difference at the level of significance p = .000 in the system of applied morphological and motor variables.

Table 2. Discriminant function significance

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	1.876(a)	100.0	100.0	.808

Key: Eigenvalue - squares of the coefficients of discrimination, Canonical Correlation- canonical correlation coefficients

Test of Function	Wilks' lambda	Chi-square	Df	Sig.
1	.348	208.616	13	**.000**

Key: Wilks' lambda - values of Bartlett's test, chi-square - significance of correlations between the examined spaces,

In order to assess the impact (effectiveness) of applied physical exercise programme, thirteen tests were done at the beginning and at the end of the programme performance, the tests that are assumed to represent a good measure of the examined morphological and motor space on the sample of preschool age participants. By examining the results shown in Table 3, it is noted that the highest contribution to the discriminant function has the test for assessment of static strength of arms and shoulder area (MSSIZD), followed by the test for assessment of the upper extremities alternative movements (MTAPRU) and standing long jump (MFESDM) with a negative sign from the mobility space, and foot length (ADUŽST), average circumference of the chest (ASROGK) with negative sign and body weight (ATEŽTJ) also with negative sign from the space of morphology.

Table 3. Standardized discriminant coefficients

Variable	Function 1
ATEŽTJ	-.207
AVISTJ	.016
POSMAS	-.136
BMINDX	-.016
AŠIRRA	.003
AOBNAT	-.059
ASROGK	-.227
ADUŽST	.313
MFESDM	-.246
MTAPRU	.338
FLAMIN	.050
MFDOSU	.095
MSSIZD	.906

Based on the correlations with discriminant function (structure of discriminant function, Table 4), thus with the variable that differentiates the initial from the final measurement to the maximum, it can be seen that the test for assessment of static strength of arms and shoulder area (MSSIZD .823) is the most responsible for achieved changes, followed by the test for assessment of the upper extremities alternative movements (MTAPRU .334) from the space of mobility and foot length (ADUŽST .258) from the morphology space.

Table 4. Factor structure of isolated discriminant function

Variables	Function 1
IZDZGIB	.823
TAPRU	.334
DUŽSTOP	.258
ATEŽTJ	-.158
AVISTJ	.137
POSMAS	-.110
FLAMIN	.095
OBNAT	-.081
BMI	-.079
DOS	.065
SDM	.042
ŠIRRAM	-.034
OBGRUD	-.013

Table 5. Centroids of the discriminant function groups

VAR00014	Function 1
1.00	-1.363
2.00	1.363

Centroids of the discriminant function groups shown in Table 5 demonstrate that the distance of the groups is equal and statistically significant.

Based on the obtained results, it can be concluded that the programme within the sports school with its content, volume and load intensity had a positive effect primarily on increase in static strength of arms and shoulder area, and then the speed of the upper extremities alternative movements. There were statistically significant global quantitative changes in the tests of static strength of arms and shoulder area and the speed of the alternative movements. The results obtained support earlier research on achieving positive effects of various kinesiological treatments on different motor skills of preschool children (Hraski and Živčić, 1996; Kostić, Miletić, Jocić and Uzunović, 2002; Deli, Bakle & Zachopoulou, 2006; Iivonen, Nissinen, Saakslahti, & Liukkonen, 2007; de Privitellio, Caput - Jogunica, Gulan, & Boschi, 2007; Hraste, Đurović and Matas, 2008; Venetsanou, Kambas, & Giannakidou, 2015), but also on morphological characteristics of children (Hraste, Đurović and Matas, 2008; Janz et al. 2009; Mesarojš-Živkov and Markov, 2010). The reason for a smaller number of selected variables of morphological characteristics where statistically significant changes occurred at global level is probably a relatively short time period in which the physical exercise programme was performed.

Based on the literature available, it can be concluded that there are not enough scientifically grounded information that speak about models of movement of preschool children, although it is known that such knowledge is very important for guided action of physical exercise on general growth and development of a child at that age. Bearing in mind the importance of physical activity of children in preschool age for their general growth and development, the need arises for planning and programming physical exercise in kindergartens based on scientific grounds. For these reasons, it would be absolutely justified for the tested physical exercise programme or at least its part of programmed educational content to be incorporated into the programme contents of preschool education. Programmed and guided physical activity has an invaluable importance for optimal growth and development of children and an indispensable form of protection and improvement of their health. With guided physical activity the children have conditions for normal growth and development, and effects on their health can be nothing but positive in the long term.

CONCLUSION

In order to determine global quantitative changes of morphological characteristics and motor skills canonical discriminant analysis was applied. Based on the results of discriminant analysis of morphological characteristics and motor skills, it can be seen that the physical exercise programme produced statistically significant changes at the global level. Variables that most contribute to distinguishing between the initial and final measurements are pull up (chin-up) endurance (MSSIZD .823) and hand tapping (MTAPRU .334) meaning that the applied physical exercise programme with preschoolers achieved the greatest increase in static strength of arms and shoulder area and the speed of alternative movements. In the space of morphological characteristics, the most contribute to distinguishing between the initial and final measurements is foot length (ADUZST .258). The results obtained can be useful to all those who in any way participate in working with children in preschool institutions (kindergartens) and can serve for comparison of results in some future research that will address research on the population of preschool children.

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DETERMINING THE DIFFERENCE IN THE REPETITIVE POWER OF THE ARM AND SHOULDER GIRTH IN STUDENTS AGED 16-18 YEARS

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SUMMARY

The aim of this paper is to determine the differences in the repetitive power of the hand and shoulder girth among pupils of Kruševac secondary schools (Economic School of Commerce, Medical School and Chemical Technology School). The research was conducted on a sample of 97 students aged 16-18 who were divided into three groups depending on which of the three schools they attend. Using the test of press-ups on the horizontal bar, the repetitive power of the hand and shoulder girth was assessed. The analysis of variance determined a statistically significant difference in the repetitive power between these three groups. The best results on the test were shown by students of the School of Economics and Trade (Mean value 7.71 press-ups)

Keywords: repetitive force, pupils, press-ups on the horizontal bar

INTRODUCTION

Repetitive power is a dynamic force that usually has a cyclical character of manifestation. For repetitive power, the stress and muscle relaxation is characteristic (repetitio = repetition). There are many examples of repetitive activity (from elementary motor activities – push-ups, press-ups, sit-ups, squats.), and in bicycling, running on medium and long run, rowing, swimming, cross-country skiing etc (Malacko, & Rađo, 2004).

Repetitive power is quite difficult to separate from endurance, although there is a difference. Some experts believe that the activities performed by repeating loads of over 30% of the maximum of the individual are in the domain of repetitive power, and those with a load below 30% of the maximum in the domain of muscular endurance (Stojiljković et al., 2005).

Repetitive power depends on a number of factors, among which it can be classified:

- Biological
- Psychological
- Sociological

Biological factors are determined by morphological factors and physiological and biochemical processes. These factors primarily make good supply of muscle with oxygen and other nutritive substances, good functioning of the cardio vascular and respiratory system primarily, as well as other organic systems. With trained athletes for repetitive power, rational energy consumption is very important, and it is achieved, among other things, primarily by the good coordination of the muscles of the agonist and antagonist. The nervous system is responsible for the state of fatigue synaptic in the activities of repetitive force, and it depends primarily on the type of individual's nervous system and on training. Morphological types of people with a higher amount of fat, ballast tissue are not favorable for repetitive force. Fat tissue in muscles causes more friction, and therefore weaker muscular contraction efficiency. Psychological factors, among which the highest is motivation, the conative characteristics and the value system, are very important for expressing the ability of repetitive force. Social conditions, primarily through the importance that the social environment attaches to physical exercise, affect the activity of repetitive power, as well as the economic status of the family and the wider community, in the case of marathon, long swim, cycling, rowing, because without adequate nutrition these activities can not be implemented, and greater material resources are needed. Repetitive power, as a form of power manifestation, can be defined as the ability of long-term muscular work, or, the ability to withstand long-term (repetitive) overcoming different types of resistance (Zaciorski, 1975; Kukolj, Jovanovic, & Ropret, 1996). If it is about overcoming external loads, we are talking about the absolute, and if we are dealing with the repeated overcoming of the weight of one's own body, we are talking about the relative repetitive force. The relative repetitive force of importance is in all activities in which athletes repeat overcoming the weight of their own body. Although there are a number of measuring instruments (tests) for estimating repetitive power that are standardized and whose metric characteristics have been checked multiple times, we nevertheless strive to construct new, better, more precise and shorter tests. The construction of tests is a complex process, because these tests must meet certain conditions. Basic conditions relate to the fulfillment of certain metric characteristics, the validity, reliability, sensitivity and objectivity. Of course, we expect from the tests already mentioned, or, it will be easy to use and last as short as possible. In this paper, one of the standard tests for the estimation of the repetitive power of the hand and shoulder girth, the performance of press-ups on the horizintal bar will be applied Soše and Rađo (1998). Motor skills are just one segment of the anthropological status of a man. They influence success in a large number of sports branches and disciplines together with morphological characteristics, functional abilities and other characteristics. **The aim** of the research was determined on the basis of the subject and the problem of research, and can be defined as: to determine the difference in the repetitive power of the hand and shoulder girth between the student groups.

METHODS

Subjects

The sample of respondents consisted of 97 secondary school students in Kruševac (Economic School of Commerce - 31 pupils, Medical school - 32 students and Chemical Technology School - 34 pupils) aged 16 to 18 years. Students were selected by random selection. The students of each of the three schools were included in a group. Testing was done at the last class of physical education at the end of the first term.

Procedure

The sample of variables consisted of only one variable for estimating the repetitive power of the arm and shoulder girth. For this purpose, the test of press-ups on the horizontal bar was applied. This test was taken from a battery of tests by Soše and Rađo (1998). Tests were conducted in physical education halls in schools attended by students who were included in the sample of respondents. This area was well lit and with a temperature of about 21 °C. The testing was carried out by two professionally trained persons, one of whom counted and checked the correctness of the performed press-ups, while the other recorded the results into a previously prepared personal card of the students. Respondents were dressed up into sportwear, and all the respondents of a group were present in the hall where the measurement was carried out. For the performance of this test, a standard-size horizontal bar was used for exercising in sports gymnastics. From the initial position of the hanging position on the horizontal bar , the respondent rises until his chin is above the level of the horizontal bar. Only successfully performed press-ups for 20 seconds are counted.

Statistical analysis

In order to make at certain conclusions, all the obtained results were statistically processed in the SPSS 20 program, whereby the central and dispersion parameters (descriptive statistics) for each group were calculated as follows: arithmetic average, minimum (Min) and maximum (Max) values, range, standard deviation (SD), variance, standard error of arithmetic mean (Std.error), symmetry of distribution of results (Skewness), and longitudinal distribution of results (Kurtosis). An analysis of variance (ANOVA) was used to determine a statistically significant difference between the investigated groups.

RESULTS WITH DISCUSSION

Table 1. Descriptive statistics for a group of students from the School of Economics and Commerce in Krusevac

	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
press-ups	31	13	2	15	7,71	,665	3,705	13,730	,316	,421	-,802	,821
Valid N (listwise)	31											

Table 2. Descriptive statistics for a group of students from the Medical School in Krusevac

	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
press-ups	32	11	1	12	5,47	,603	3,412	11,644	,285	,414	-1,067	,809
Valid N (listwise)	32											

Table 3. Descriptive statistics for a group of students from Chemical Technological School in Krusevac

	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
press-ups	34	12	0	12	6,10	,571	3,330	11,088	-,149	,403	-,913	,788
Valid N (listwise)	34											

Tables 1, 2 and 3 show the results of the central and dispersion parameters for all three groups included in the study. The discriminatory measurement was estimated based on the variability of the obtained results. In all three groups within the range (Range) between the minimum and maximum values, there are less than 6 standard deviations, based on which the reduced sensitivity or discrimination of the applied test of press-ups on the horizontal bar can be concluded. The symmetry of the distribution of the results is estimated based on the skewness. In all three groups, the values of the skewness indicate a normal symmetric distribution of the results. The homogeneity of the distribution of the obtained results is assessed on the basis of the kurtosis and in all three cases we have a normal mesocentric distribution.

Table 4. KS test - first group (Economics and Commerce School)

N		31
Normal Parameters[a]	Mean	7,71
	Std. Deviation	3,705
Most Extreme Differences	Absolute	,114
	Positive	,114
	Negative	-,073
Kolmogorov-Smirnov Z		,634
Asymp. Sig. (2-tailed)		**,816**

Table 5. KS test - second group (Medical school)

N		32
Normal Parameters[a]	Mean	5,47
	Std. Deviation	3,412
Most Extreme Differences	Absolute	,124
	Positive	,124
	Negative	-,095
Kolmogorov-Smirnov Z		,703
Asymp. Sig. (2-tailed)		**,706**

Table 6. KS test - third group (Chemical-technological school)

N		34
Normal Parameters[a]	Mean	6,10
	Std. Deviation	3,330
Most Extreme Differences	Absolute	,093
	Positive	,093
	Negative	-,085
Kolmogorov-Smirnov Z		,543
Asymp. Sig. (2-tailed)		**,930**

Table 7. Results of variance analysis

ANOVAress-ups					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	83,919	2	41,960	3,464	**,035**
Within Groups	1138,746	94	12,114		
Total	1222,665	96			

Tables 4, 5, and 6 show the results of the Kolmogorov Smirnov test to check the normal distribution in each of the three groups. Values are in all three groups greater than ,05 indicating a normal distribution.

The value, 035 shown in Table 7, indicates a statistically significant difference in variance. In order to further determine the difference between each of the examined groups and which of these differences contributed to the difference between the groups in the ANOVA results, the Post-Hok Tukhi's test was applied. The Tukhi's test is used only if the homogeneity of the variance has been determined previously.

Table 8. Results for the assessment of the homogeneity of the variance

Levene Statistic	df1	df2	Sig.
,278	2	94	,758

Table 9. Results of the Tukhi Post-Hock test

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
first group	second group	2,241*	,877	,032	,15	4,33
	third group	1,607	,864	,156	-,45	3,67
second group	first group	-2,241*	,877	,032	-4,33	-,15
	third group	-,634	,857	,741	-2,68	1,41
third group	first group	-1,607	,864	,156	-3,67	,45
	second group	,634	,857	,741	-1,41	2,68

The mean difference is significant at 0.05 level.

Based on the results of the Tukhi Post-Hok test, it was found that the difference between the first and the second group was statistically significant until the differences between the first and third, as well as the second and third groups, were not statistically significant.

CONCLUSION

On the sample of 97 pupils from Kruševac secondary schools (School of Economics, Medical School and Chemical Technology School), which were divided into groups from one of these three schools, a transversal type of research was used to determine differences in repetitive power arm and shoulder girth. In the study, one variable for estimating repetitive power (press-ups on the horizontal bar) was measured, and the analysis of variance at the univariate level (ANOVA) was used to determine the differences between the investigated groups. On the basis of the obtained results we can conclude that ANOVA has established a statistically significant difference between the examined groups indicating the existence of a difference in the repetitive power of the hand and shoulder girth between secondary school students in Kruševac. There was a statistically significant difference between the students of the School of Economics and Trade and the Medical School.

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REPRESENTATION OF LANGUAGE COMPETENCES IN THE EARLY YEARS OF CHILDREN'S EDUCATION PROCESS

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SUMMARY

The ability to use symbols, and within that scope, the ability to speak has distinguished man from other animal species. Language has a central place in the cognitive processes of the child, because it helps in systematizing everything that the child has seen or experienced. It has been established that by mastering the native language and its use, a multitude of logical activities occur and in this way the language, in addition to being a means of communication, appears as a means of knowledge, enabling not only presenting experiences but also transforming them. Not only expression, but also the creation of new thoughts. In this context, native language programs have their own specificity which requires a special approach in each country, that is, each national curriculum, since it treats the study of the language in which usually the entire teaching is performed (instruction in all subjects). In our comparative review, we focused on the representation of the subject native language on a weekly and yearly basis, as well as the representation in relation to other subjects in: Macedonia, Austria, Slovenia, Croatia, Serbia and Bulgaria. We do all of this in order to determine the importance of the language competences of the children of preschool and early school age, through treatment and representation in the educational process.

Keywords: development of speech in children, learning native language in schools, curriculum,

INTRODUCTION

In ontogeny, the symbolic function occurs during the second year of life when the ability to create an idea for an object appears, and to create a symbol for the idea. Speech as the most perfect semiotic system is followed by a series of parallel semiotic systems, such as: image, graphic, gesture, rituals, etc. At the same time, semiotic systems "create a different kind of reality: "an inner world shaped by symbolic means - internal speech, thinking for onetself, and, ultimately, a private subjective world as a whole, consciousness and self-consciousness". (Ivic, 1978). In pedagogical science, the problem of the development of the student's cognitive processes and their importance in teaching is highlighted in particular. The results of the research in the developmental psychology for this crucial problem have special significance for the planning and organization of the teaching, and especially for the selection of the contents, methods and activities in the teaching process. It is known that from the rich treasury of knowledge, skills and values of mankind that has been created for centuries, it is not possible, nor there is a need for students to internalize it all. With quantity, the quality of knowledge and values is often lost, because of the generality the efficiency decreases, and the reasons for the overcapacity of the curricula lie in the non-differentiation of the content. In fact, not enough care is taken about the cost-effectiveness of knowledge, because the curriculum does not always contain adequate content for broad, complete and effective influence on the development of students' intellectual abilities.

From the study of this problem, in 1960, Bruner in his study "The Process of Education" presented his positions on the role of the curriculum in teaching and learning. According to Bruner, the curriculum consists of the following components: 1) there must be clear intentions - the main purpose of the curriculum has to be clear; 2) to have clear views on the question of which contents of contemporary culture should be included in the curricula (from natural and social sciences with higher values and of less knowledgeable character); 3) he states there are several conditions to fulfill for quality teaching, and the first condition is to emphasize the structure of knowledge in the teaching content; 4) to remove all those methodical procedures that do not allow independent critical discovery of the important concepts and relationships between them from learning and teaching. According to Bruner's perceptions, the basic concepts, laws, and principles should be the main elements in the structure of the content. Bruner also reviews the content structure functions: for example, the student can use the structure to perceive and understand the underlying idea because it is a prerequisite for understanding the whole subject matter. With the basic ideas the student gets complete visibility for understanding the laws, ie the reasons and consequences in the contents that are structured in the subjects. This didactic function highlights the student's attitude to the content they learn, but according to Bruner, the structure of the content is not only a means for quickly and comprehensively understanding the content, but also a means for easy and rational memorization of the learned contents in the learning process. The student will remember the data easily if he/she involves it in a structure or system.

Starting from the rich theoretical and empirical treasury, in European countries with a long educational tradition, it can be noted that language competences are at the forefront of key competences in pre-school and early school age. Although the approaches in creating curricula are country-specific, there are some comparing components that provide us with useful knowledge in order to advance the language competences of preschoolers and early school children. The aim of our research is directed towards perceiving the treatment and representation of language competences in the national curricula of different countries from Europe and the Republic of Macedonia.

METHODS

Subjects

Subjects were school children from first development period (from grade one to third grade), according to the national curriculum of each of the listed countries.

Procedure

In our research, we focus on the comparative indicators for the coverage of the native language subject in the national curricula of: Slovenia, Croatia, Serbia, Bulgaria, Austria and Macedonia.

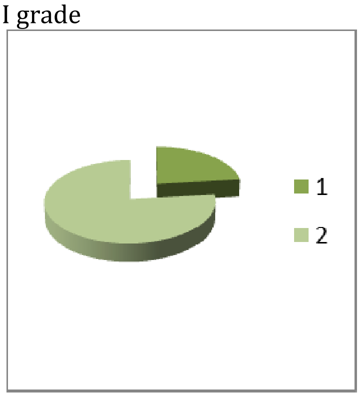
Statistical analysis

We measure the percentage of the total number of classes for the first development period (from grade one to third grade), according to the national curriculum of each of the listed countries; the percentage of the teaching subject in relation to other subjects that are part of the curriculum for the same age of children; comparative representation of the subject native language from grade one to third grade, between the curricula of the listed countries.

RESULTS AND DISSCUSION

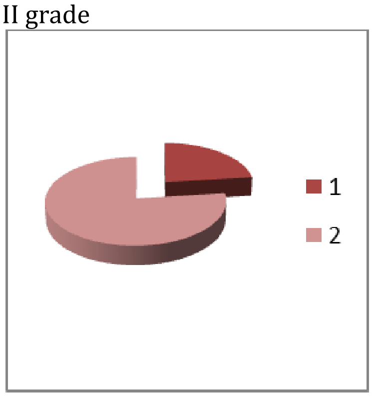
Table 1. Percentage of classes in the subject Slovenian language in relation to the total number of classes per grade in the first development period annually:

I grade



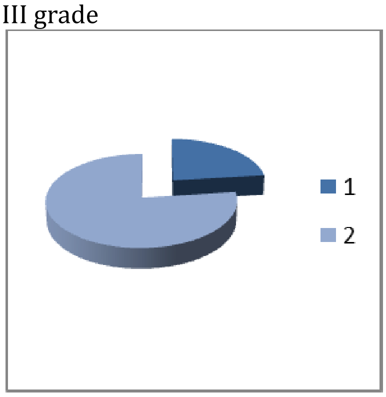
1-Classes in subject - Slovenian language 30%
2-Total number of classes 70%

II grade



1- Classes in subject - Slovenian language 35%
2- Total number of classes 65%

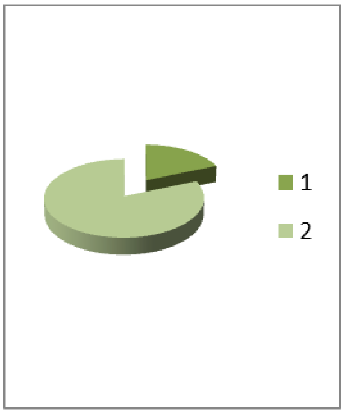
III grade



1- Classes in subject - Slovenian language 35%
2- Total number of classes 65%

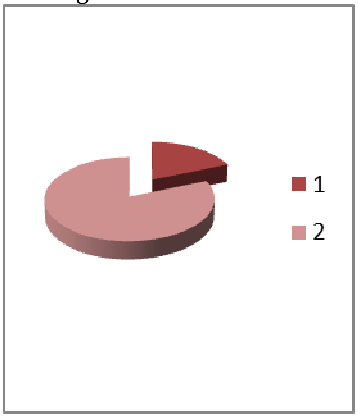
Tabel 2. Percentage of classes in the subject Croatian language in relation to the total number of classes per grade in the first development period annually:

I grade



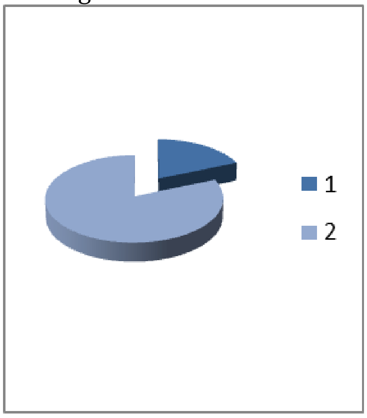
1. Classes in subject - Croatian language 22,9%
2. Total number of classes 77,1%

II grade



1. Classes in subject - Croatian language 22,9%
2. Total number of classes 77,1%

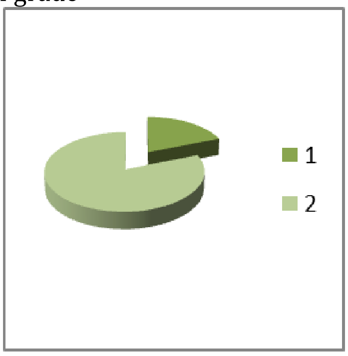
III grade



1. Classes in subject - Croatian language 22,9%
2. Total number of classes 77,1%

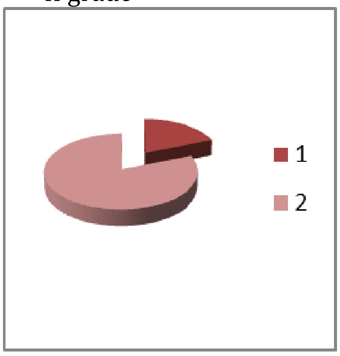
Tabel 3. Percentage of classes in the subject Serbian language in relation to the total number of classes per grade in the first development period annually:

I grade



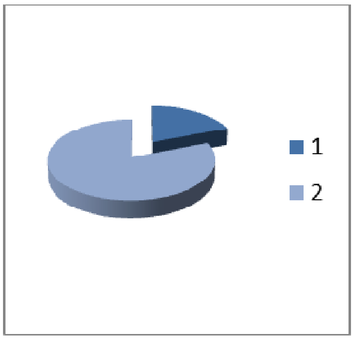
1. Classes in subject - Serbian language 23,5%
2. Total number of classes 76,5

II grade



1. Classes in subject - Serbian language 23,5%
2. Total number of classes 76,5

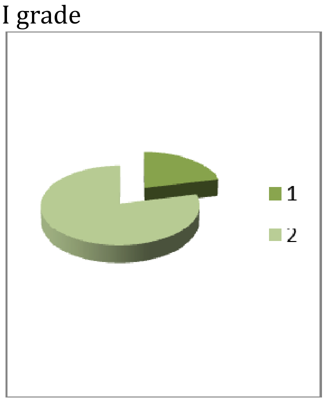
III grade



1. Classes in subject - Serbian language 23,5%
2. Total number of classes 76,5

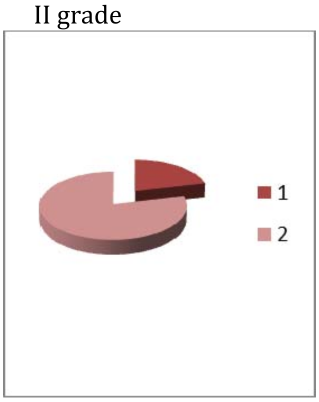
Table 4. Percentage of classes in the subject Bulgarian language in relation to the total number of classes per grade in the first development period annually:

I grade



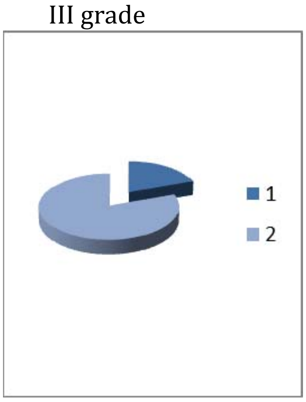
1. Classes in subject - Bulgarian language 27%
2. Total number of classes 73%

II grade



1. Classes in subject - Bulgarian language 27%
2. Total number of classes 73%

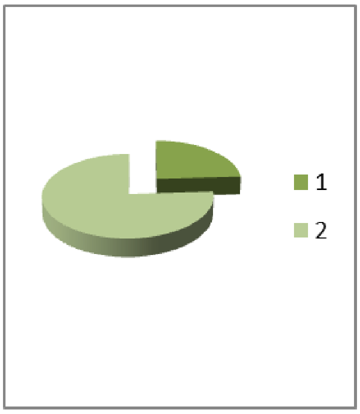
III grade



1. Classes in subject - Bulgarian language 24,1%
2. Total number of classes 75,9%

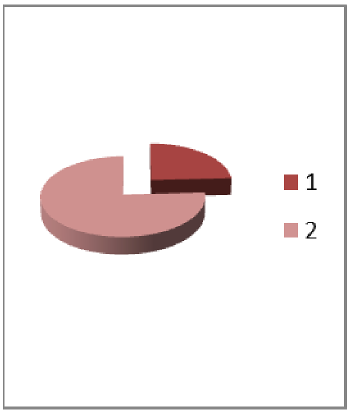
Table 5. Percentage of classes in the subject German language in relation to the total number of classes per grade in the first development period annually:

I grade



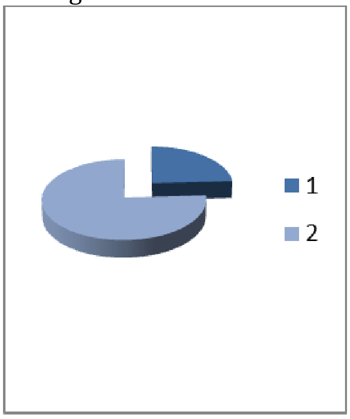
1. Classes in subject - German language 29%
2. Total number of classes 71%

II grade



1. Classes in subject - German language 29%
2. Total number of classes 71%

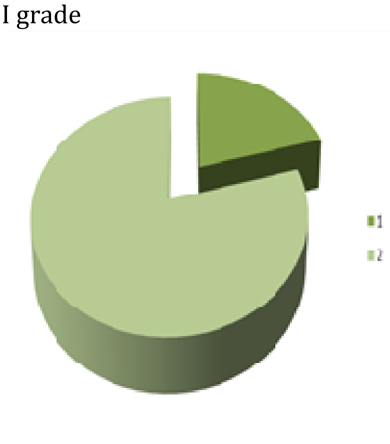
III grade



1. Classes in subject - German language 29%
2. Total number of classes 71%

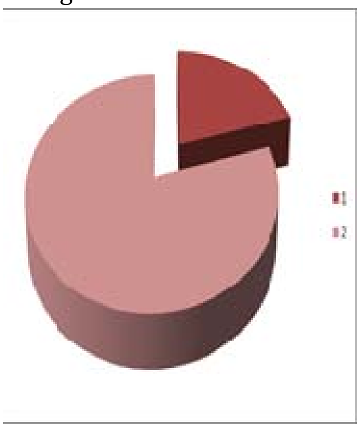
Table 6. Percentage of classes in the subject Macedonian language in relation to the total number of classes per grade in the first development period annually:

I grade



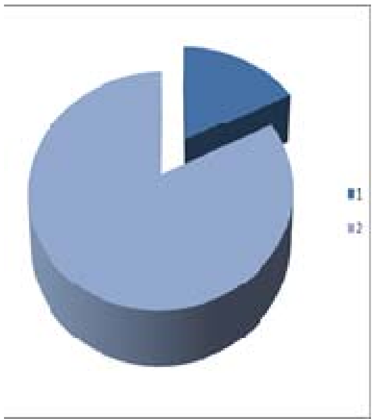
1. Classes in subject - Macedonian language 26,08%
2. Total number of classes 73,92%

II grade



1. Classes in subject Macedonian language 26,08
2. Total number of classes 73,92%

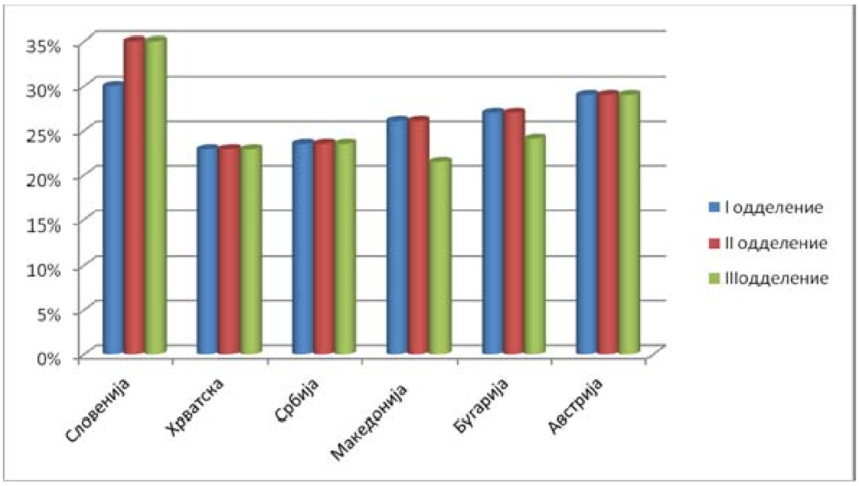
III grade



1. Classes in subject - Macedonian language 21,47%
2. Total number of classes 78,53%

The previously expressed percentage differences ranging from 22.9% to 30% can be seen in the graph below. They show us that the German language in Austria and the Slovenian language in Slovenia, and after them the Bulgarian language in Bulgaria, have the highest number of classes in the first development period. Macedonia follows their example, and is followed by Croatia and Serbia.

The number of classes varies from 5 to 7 per week, but the total number of classes for other subjects is also a factor that has made a big change in the review we were doing. Another key factor that was at in fact related to the number of classes is the coverage of the reading and writing categories in the first grade. Namely, in countries where the full literacy of students is carried out in the first grade, there is a higher number of classes for the subject native language, which is seven. The same curricula have areas that include reading and writing in the second and third grades, and the number of classes is not reduced.



CONCLUSION

D The results of our research show that the early definition of language competences and their incentive in the early pre-school and school stage is particularly emphasized in the national curricula of most countries in relation to other subjects, and represents a basis for successful achievement of the set objectives and standards in the teaching process. In the end, we can conclude that the openness in the number of classes and the concreteness of what we want to achieve in accordance with the specifics of the language we speak can be a good path to achieve the goal - solid literacy, and thus ready students to face various scientific and artistic challenges, for which language competencies are the key to going forward.

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YOGA PRACTICES IN KINDERGARTEN

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SUMMARY

Childhood is a period of intense physical, emotional, cognitive and behavioural education and is subject to social and cultural influences. Over the last few decades, yoga has become an activity enjoyed all over the world, not just by adults and the elderly but also children. Yoga helps to strengthen muscles and improves body flexibility. It is suitable for clumsy children and people too. Yoga practice incorporates movement, dynamic breathing techniques, meditation. It can be a plausible intervention in the kindergarten that can lead to individual and social benefits. Yoga sessions acquaint children with exercises that can be used in various contexts, such as before going to bed, or during emotionally challenging times at work or at home. Participants become more positive, open to the others and so they improve their social lives .Learning yoga physical postures builds confidence in children. Purpose of our study was to examine the influence of practicing yoga on development among 5-7-year-old children.

Key words: yoga, children, fitness tests

INTRODUCTION

Over the last few decades, yoga has become an activity enjoyed all over the world, not just by adults and the elderly but also children. Yoga helps to strengthen muscles and improves body flexibility. It is suitable for clumsy children and people (O'Neil, Ideishi, Benedetto, Ideishi, & Fragala-Pinkham, 2016). Yoga practice incorporates movement, dynamic breathing techniques, meditation. It can be a plausible intervention in the kindergarten that can lead to individual and social benefits (Chen, & Pauwels, 2014). Yoga sessions acquaint children with exercises that can be used in various contexts, such as before going to bed, or during emotionally challenging times at work or at home. Participants become more positive, open to the others and so they improve their social lives. (Harris, 1963; Bhushan, 2003). Purpose of our study was to examine the influence of practicing yoga on development among 5-7-year-old children. Attention was paid to pedagogical interactions during yoga training (views, convictions, conceptions, how children feel themselves). Our primary focus was the application of safe yoga exercises as a structural component of physical education classes for nursery school children. Chen, D. D., & Pauwels, L. (2014). Perceived Benefits of Incorporating Yoga into Classroom Teaching: Assessment of the Effects of "Yoga Tools for Teachers." *Advances in Physical Education*, *04*(03), 138–148.

METHOD

The examination was carried out in the Svetlina ("Light") Nursery School in the town of Stara Zagora, Bulgaria, for six months during the 2016/2017 school year (October 2016 - March 2017). Study was conducted with 86 children – 40 boys and 46 girls, aged 5-7 years-old, who formed four mixed-gender groups. Yoga practices were incorporated every day in the morning to say "Hello" to the sun and in children's regular PE lessons (*photo 1 and photo 2*). Parents were informed about their children's activities. (Hristova, 2008).

Photo 1.Yoga practice in the morning to say "Hello" to the sun – one of the groups

Photo 2. Yoga practice during PE lessons

Over the six month study period, teachers observed

(1) Children's interest in the exercises,
(2) Parents' attitudes to their children's yoga activities,
(3) Children's absences due to illness,
(4) Children's intellectual development, using the "draw-a-person".
(5) Children's readiness for school,
(6) Changes in height and weight.

RESULTS WITH DISCUSSION

Simple yoga exercises were suitable for and met with satisfaction and interest by all children. Basic yoga poses were introduced to the children in the form of a play. Children enjoyed representing different animals (a dog, a snake, a frog, etc.) using their bodies. Children's mastery and success in yoga practices depended on their parents' interest and attitude too. Children whose parents showed interest and support for their child's yoga activities had better results. Absences from the nursery school under study were minimal (n = 7%). In regular nursery school classes, absence rates are usually between 20 and 30%, depending, for example, on emergent influenza infections.

Table 1. A great number of the participants in the yoga exercises had good physical fitness.

Extent	Name of the test											
	40 m run (s)		**Standing long jump (cm)**		**Throwing a 1kg ball (cm)**		**Throwing a 150g ball for distance (m)**		**Curl-up test (number)**		**Squats for 20 s (number)**	
	$\overline{X}_1$	$\overline{X}_2$	1	2	1	2	$\overline{X}_1$	$\overline{X}_2$	1	2	1	2
B O Y S												
high			105	130								
middle					290	300		8,80	12	16	17,7	19,9
low	12,2	11,4					7,00					
G I R L S												
high			103	119		270						
middle	12,2	11,6			255		5,40	6,20	13	18	16,7	19
low												

Differences between girls and boys were statistically insufficient. Here we want to say also that it is not necessary to connect the good physical fitness with good physical health as physical health depends on psychic and social health too, in the context of the holistic approach to the phenomena in the Nature and the world. If we are more realistic, we have to say that strength, endurance, balance, aerobic capacity, etc. of children are first of all genetically determined (Vallejos, Ball, Brown, Crepaz-Keay, Haslam-Jones, & Crawford, 2016). Height and weight of children were in normal terms and there was not a boy or a girl with overweight. The average height of the at the beginning and at the end of the experimental period. In the context of the psychic, mental and social children and to determine their intellectual age we used the F. Goodenough test "draw-a-person". On the base of their scores children were divided into four groups (F. Goodenough scoring) (Valkova, 2012).

Group A included children with a high IQ (IQ = 149-183). On the basis of their test scores, 16 children had an intellectual age of 11-years-old, 8 children an intellectual age of 12-years-old, 12 children an intellectual age of 10-years-old, 4 children an intellectual age of 9.5-years-old, and 12 children an intellectual age of 9-years-old. Totally group A envelops 52 children or 60. 5 % and all of them seriously with 2 to 4 years exceed the intellectual age of their coevals. We assume reason for this is mainly the influence of the electronic media and the great information nowadays that floods children from everywhere.

Group B with IQ = 119-149 included 14 children (9 with an intellectual age of 8 and 5 with an intellectual age of 8.5).

Group C comprised children with IQ =108-119. Six children (7 %) had a mental age of 7 and 5 a mental age of 7.5.

Group D enveloped children with a lower IQ = 95-108 and a mental age of 6.5. Nine children or 10.5% of the sample were part of this group.

In our study totally in 15 children (17.5 %) – group C and D, intellectual and calendar age coincide. Yoga exercising can play a role in preparing children to go to school. It is not a competitive activity, but yoga helps improve children’s flexibility, co-ordination of movements, and kinesthetic awareness. It also helps them master their emotions, similar to study Folleto, Pereira, & Valentini (2016). No aggression or hyperactivity was registered among the children who practiced yoga.

CONCLUSION

Yoga is good for all ages. Yoga poses and exercises can be offered to children still in kindergarten age. Such practices exist in many countries all over the world but the statistics in this attitude is too poor. What can be seen in Internet is that yoga is becoming increasingly popular among American children.

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