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Research article

EFFECTS OF A 12-WEEK AEROBIC TRAINING PROGRAM ON THE COGNITIVE AND MOTOR ABILITIES OF PRESCHOOL CHILDREN

UDC 796.015.012.1:159.9

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Abstract. *The aim of this longitudinal study was to determine the effects of aerobic training on the cognitive and motor abilities of preschool children. The sample of participants included 47 preschool children aged five to seven. The participants were randomly divided into two groups: the experimental (n=25, 6.35±0.32yrs) and the control group (n=22, 5.90±0.27yrs). The experimental group took part in aerobic training for children over a 12-week period at a rate of three training sessions per week, 30min each. To evaluate the children's cognitive abilities, the school maturity test was used, or more precisely, three of its subtests: visual memory, stacking cubes, and codes. To evaluate their motor abilities, the BOT-2 (Bruininks-Oseretsky Test of Motor Proficiency) battery of tests was used, that is, its subtests: fine motor integration, manual dexterity, bilateral coordination, and balance. The children completed a total of 77 tasks, of which 48 were cognitive and 29 motor, both at the initial and the final measurement. Finally, the paper analyzes a total of 10 variables, four cognitive and six motor, which represent the total standardized values based on gender and age for each of the abilities. No significant effect of the training was determined for any of the cognitive abilities variables. The results indicate that aerobic training had significant effects on the following motor variables: fine motor skills (p=.020), bilateral coordination (p=.000), motor balance (p=.001), and body coordination (p=.000). A significant effect was determined for all four variables. We can conclude that aerobic training can represent an excellent means for the psycho-physical development of preschool children.*

Key words: *aerobic exercise, motor abilities, cognition, preschoolers, BOT-2*

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INTRODUCTION

The preschool age ranges from the ages of three to seven, and in practice is divided into: the younger preschool age from the ages of three to four, the middle preschool age from the ages of four to five, and the older preschool age from the ages of five to six, that is, until the child begins school (Milanović & Stamatović, 2004). The preschool age is considered one of the most important phases in the entirety of personality formation (Bala, 2002). During this phase physical activity represents a key component of a child's life, since children learn precisely through movement and motion, and thus begin to understand themselves and the world around them (Zimmer, Christoforidis, Xanthi, Aggeloussis, & Kambas, 2008). It is known that physical activity represents the basis of early childhood development and also affects various aspects of health (King et al., 2003), so what should be singled out in particular is its positive effect on the motor, emotional, and cognitive domain (US Department of Health and Human Services, 2008). The greatest effect of physical exercise was noted in the domain of executive functions which are of considerable importance for everyday motor performance, for behavior adaptability among children, their intellectual functioning, and academic success (Tomporowski, McCullick, Pendleton, & Pesce, 2015).

Recently more and more studies indicate the effectiveness of aerobic activities which include physical exercise of low to high intensity, which in turn primarily depends on aerobic energy production (Plowman & Smith, 2013). The National Association for Sport and Physical Education (NASPE, USA) recommends that children aged five to 17 should have at least 60min of moderate to high intensity exercise daily, with the addition that an advantage should be given to aerobic activities (Guan et al., 2020). Research indicates that aerobic physical activity generates structural changes in the brain, such as neurogenesis, angiogenesis, and an increase in the volume of the hippocampus (Chaddock et al., 2010, Thomas, Dennis, Bandettini, & Johansen-Berg, 2012; Stojiljković, Mitić, & Sporiš, 2019). Among children, a positive association between aerobic conditioning and the volume of the hippocampus results in an increase in memory and retention, as well as in the regulation of stress (Chaddock et al., 2010, Thomas et al., 2012). Neurogenesis and increased connections in the white matter were also noted in certain studies as a response to this type of training (Thomas et al., 2012; Krafft et al., 2014). These changes in the structure and function of the brain are positively associated with an improvement in certain cognitive functions such as inhibition, working memory, and learning (Chaddock, Pontifex, Hillman, & Kramer, 2011), which are closely linked to success in school (Tomporowski, et al., 2015) and academic achievement (Lees & Hopkins, 2013).

The effect of exercise on the motor development of children is an increasingly more prevalent topic, and numerous studies have determined that physical exercise has a positive effect on the motor skills of preschool children (Dobrila, Sporiš, & Hraski, 2003; De Privitellio, Caput-Jogunica, Gulan, & Boschi, 2007; Alwasif, 2013; Krneta et al., 2015; Bellows et al., 2017; Birnbaum et al., 2017; Jaksic et al., 2020). The most frequently noted improvements are to: explosive strength, repetitive strength, coordination, speed, and flexibility. When it comes to the effects of specific aerobic training on the motor development of children, it was determined that the given activities have a positive effect on motor skills, and that particularly better results are achieved for obstacle course racing and reverse running, while the results for the balance test were the same as those for the standard program of physical exercise (Puder et al., 2011).

Based on the existing body of information which speaks to the positive impact of aerobic training on structural and functional changes in the brain of a child, the aim of this study was

to analyze the specific effect of aerobic training on certain cognitive functions. At the same time, when it comes to motor development, the aim was to study the impact of aerobic training on abilities which were not sufficiently studied or for which there were no clear findings, such as: fine motor skills, coordination, and balance. Bearing this in mind, the aim of this study was to determine the effects of a 12-week aerobic exercise program on the motor and cognitive abilities of preschool children.

METHODS

Participants

This longitudinal study included 47 participants, all preschool children. The participants were randomly divided into two groups: the experimental (n-25, 6.35±.32 yrs) and control group n-22, 5.90±.27yrs). The inclusion criteria and selection of participants were based on the following: healthy children of both genders, aged five to seven, who were not taking part in any organized form of physical exercise. This study was approved by the Faculty of Sport and Physical Education in Niš (Ref. No. 04-1186/2) and was conducted under the Declaration of Helsinki. All of the parents and guardians of the participants, prior to the study, voluntarily gave their written consent for the children to participate.

Procedures

Testing in this experimental study was carried out immediately prior to the (initial measurement) and after the implemented experimental exercise program (the final measurement) in the gymnasium of the "Ljubica Vrebalov" preschool in Požarevac. All of the testing, as well as the experimental program, took place in the gymnasium of the "Ljubica Vrebalov" preschool. The testing was always carried out at the same time (11h), so as to preclude daily variations in the measurement. The air temperature in the room during testing ranged from 22ºC to 26ºC.

Instruments

Cognitive skills

To identify certain cognitive functions that significantly contribute to cognitive development of preschool children, the school maturity test (in Serbian: *Test zrelosti za školu*, TZŠ+) was used, which consists of the following five subtests: a visual vocabulary, informedness levels, visual memory, stacking cubes, and codes (Novović, Biro, Baucal, & Tovilović, 2007). The TZŠ+ indicated a high reliability and validity on a sample of children aged five and a half to seven and a half, and it was suggested that there is a high correlation between TZŠ+ and the TIP-1 cognitive tests and the Raven's Coloured Progressive Matrices (Novović, Tovilović, Jovanović, & Biro, 2009).

This study included three subtests: visual memory, stacking cubes, and codes. The visual memory test is aimed at evaluating memory and attention, and consists of 15 tasks. The stacking cubes test is meant to evaluate visual-motor coordination, perceptive organization, and the ability to plan, and consists of eight tasks. The code is a test used to evaluate the ability to learn from experience, concentration, and visual-motor coordination, and it contains 25 tasks. The cognitive tests were carried out by a psychologist. The results

obtained for all three tests were converted using the standardized TZŠ+ table based on gender and age, and the obtained values were further analyzed.

Motor abilities

To evaluate the motor abilities, the subtests from the BOT-2 (Bruininks-Oseretsky Test of Motor Proficiency) battery of tests were used. BOT-2 is used as the standardized measure of the level of motor proficiency of children and adolescents from the ages of four to 21, and includes four areas: fine manual control, manual coordination, physical coordination, and strength and agility (Deitz, Kartin, & Kopp, 2007). Previous research in this field has shown that the BOT-2 test is quite valid (Abbas, Shanker, & Krishnan, 2011).

For the purpose of this study the following subtests were used: fine motor integration (eight tasks), manual dexterity (five), bilateral coordination (seven), and balance (nine). In addition, the overall values were converted based on the standardized BOT tables in relation to gender and age, and the results were further analyzed.

Variables

Every child took part in 77 cognitive and motor tasks, both at the initial and final measurement, of which 48 were cognitive and 29 were motor tasks. The aforementioned 48 cognitive tasks were divided into three subtests from which three variables were obtained and then converted based on gender and age, resulting in three standardized variables: Visual memory, Stacking cubes, and Code, while the fourth variable Cognitive abilities total represents the total mean value of the given variables.

Also, the children took part in 29 motor tasks, divided into four subtests. Once the data were converted based on standardized tables, four variables were obtained: Fine motor integration, Manual dexterity, Bilateral coordination, and Balance. The remaining two were defined by Fine motor skills which represents the sum of fine motor integration, and manual dexterity, while Body coordination represents the sum of bilateral coordination, and balance. For the purpose of further study, the paper analyzed the ten aforementioned variables.

The experimental program

The aerobic exercise program was carried out three times a week for a period of 30min, over 12 weeks. The program was designed based on the guidelines of leading health institutions and authors from the field (Baquet et al., 2003; Corbin et al., 2004; US Department of Health and Human Services, 2008; World Health Organization, 2010; Virgilio, 2011; Fahey, 2013; Garzon, 2018).

The aerobic training lasted for 30min and consisted of three parts: the warm-up, main activity, and the cool-down (Table 1). The warm-up takes place at the beginning of every aerobic training. This phase lasts approximately 5min and includes aerobic dynamic exercise which includes marching or light skipping with simultaneous shaping exercises.

The main part of the aerobic training lasts for approximately 20min, in accordance with recommendations that indicate that the duration of aerobic activities should be at least 10min (Garzon, 2018). During this phase, intervals of high intensity (30sec) alternate with periods of low intensity exercise (30sec), which is in accordance with the guidelines of aerobic interval training (Garzon, 2018). One complex, which includes one

exercise of higher and one of lower intensity, is repeated twice, and is then followed by the next complex. In total there are usually 8 to 10 complexes.

The cool-down concludes each aerobic training. This phase lasted approximately 5min. It includes aerobic activities of low intensity (slow marching in place and stretching with breathing exercises) for the heart rate to be reduced to the pre-exercise level. When it comes to stretching exercises, it is necessary to hold each position for 10-15sec.

Table 1 An overview of the aerobic training

Training session	Activity	Duration
Warm-up	Low intensity aerobic exercise and shaping exercises	5 min
Main activity	Complex: 1 exercise of high 30" - 1 exercise of low intensity 30" x2 (8-10 complexes)	20 min
Cool down	Low intensity aerobic exercise along with stretching and breathing exercises	5 min

Statistical analysis

For all of the data obtained during the testing, the descriptive statistics (basic central and distribution) parameters were calculated: the mean (Mean), and standard deviation (St. dev.). To determine the effects of the experimental program, the combined analysis of covariance was calculated ANOVA 2x2 (group x time). The level of statistical significance was set at $p<0.05$, while the effect size was represented by the partial Eta squared in the same table, whereby based on Cohen's recommendations values of up to 0.01 have a small effect size, up to 0.06 and above a medium, and over 0.138 have a large effect size (Cohen, 1988). The data were analyzed in the IBM SPSS Statistics 26 software (Statistical Package for Social Sciences, v26.0, SPSS Inc., Chicago, IL, USA).

RESULTS

Table 2 shows the general sample indicators. The aerobic group numbered 25 participants, unlike the control group which numbered 22. A difference was also noted in gender; namely, in the aerobic group there were more boys than girls, while in the control group the situation was reverse. The average age of the children in the aerobic group at the initial measurement was 6.35yrs, while in the control group it was 5.90yrs. This small mean difference which is in favor of the aerobic group is in alignment with the other parameters, and so the aerobic group has a somewhat greater body mass, body height, and BMI than the control group.

Table 3 shows the total standardized values of all the cognitive and motor subtests. Descriptive parameters were calculated for all the measured variables, that is, the mean and standard deviation, both at the initial and the final measurement. In addition, in the same table we also find the results of the combined analysis of variance - ANOVA (2x2), that is, the F value of the given test, the statistical significance, as well as the partial Eta squared which indicates the effect size.

A combined analysis of variance rated the effect of aerobic training on motor and cognitive abilities of the experimental group compared to the control group which carried out its usual activities.

No significant effect of aerobic training was achieved on any of the tests when compared to the results of the control group: Visual memory (p=.139), Stacking cubes (p=.351), Code (p=.480), and Cognitive abilities total (p=.751).

When it comes to the fine motor abilities tests, no significant effect of aerobic training was noted on the Fine motor integration test (p=.55), or on the Manual dexterity test (p=.313). But even with the given results, a significant effect was noted for the experimental program for the variable of Fine motor skills (p=.020).

A significant effect of the experimental program was noted on the tests of motor coordination for all the variables, including: Bilateral coordination (p=.000), Balance (p=.001), and Body coordination (p=.000). For all four variables in which a significant effect was noted, based on the partial Eta squared, a large effect size was noted.

Table 2 General indicator of the sample

	Aerobic group	Control group
Number	25	22
Sex	Boys: 14 Girls: 11	Boys: 9 Girls: 13
Age	Initial: 6.35±0.32 Final: 6.59±0.32	Initial: 5.90±0.27 Final: 6.14±0.27
Body weight (kg)	25.08±4.28	22.60±3.60
Body height (m)	1.22±0.05	1.17±0.05
BMI (kg/m2)	16.90±1.95	16.42±1.65

Table 3 ANOVA repeated mesures (2x2) aerobic and control group

Variables	Aerobic group		Control group		F	p	η_p^2
	Initial	Final	Initial	Final			
Visual memory	3.12 ± .60	3.00 ± .29	3.14 ± .35	3.27 ± .46	2.272	.139	.048
Stacking cubes	4.08 ± .91	4.04 ± .79	4.41 ± .67	4.18 ± .80	.887	.351	.019
Code	3.24 ± .78	3.60 ± .65	3.23 ± .61	3.41 ± .67	.506	.480	.011
Cognitive skills total	3.48 ± .57	3.55 ± .43	3.59 ± .40	3.62 ± .46	.102	.751	.002
Fine motor integration	13.36 ± 3.16	13.84 ±3.64	13.41 ± 3.83	11.82 ± 2.26	3.883	.055	.079
Manual dexterity	9.80 ± 3.64	12.52 ± 4.57	12.91 ± 4.26	14.00 ± 4.69	1.039	.313	.023
Fine motor total	23.16 ± 4.58	26.36 ± 6.83	26.32 ± 6.16	25.82 ± 5.48	5.797	**.020**	.114
Bilateral coordination	15.60 ± 3.24	18.96 ± 2.41	16.55 ± 1.99	16.68 ± 2.77	14.776	**.000**	.247
Balance	13.64 ± 4.22	15.80 ± 3.88	15.27 ± 3.01	13.27 ± 3.65	12.563	**.001**	.218
Coordination total	29.24 ± 6.40	34.76 ±5.64	31.82 ± 3.32	29.95 ± 5.43	21.035	**.000**	.319

Note: F- F statistic; p – significant; η_p^2-partial eta squared.

DISCUSSION

This study evaluated the effectiveness of a 12-weeks aerobic training on cognitive and motor abilities in preschool children. Effects on chosen cognitive functions remain inconclusive, because there was no significant improvement in the examined cognitive

functions during the 12 weeks of training. Significant improvements in fine motor skills, bilateral coordination, balance, and body coordination were observed in the intervention group when compared to the control group. Taken together, findings from this study suggest that aerobic training contributes to the development of motor abilities of preschoolers.

Even though numerous studies have confirmed that cognitive abilities increase during physical activity (Graham & Parker, 2003), the results of our study indicate the contrary, and point out that the aerobic program did not have a significant effect on the chosen cognitive functions of preschool children. Authors who studied the specific impact of aerobic training among children also noted positive effects on cognitive abilities (Reed et al., 2010; Fisher et al., 2011). In the aforementioned study, positive effects were achieved on the cognitive abilities evaluated by: Raven's Coloured Progressive Matrices, the CANTAB test of the visuospatial working memory capacity, and the ANT test used to assess efficiency.

Even though many studies suggest that exercise can increase the volume of a child's brain, have a positive effect on the structure and function of the brain, and improve a child's cognitive abilities and academic achievements (Hillman et al., 2009), not achieving these expected results in our study can be accounted for by the small sample, and/or the insufficient duration of the program itself. And certainly, we should bear in mind the analysis of Stojiljković et al. (2019) who determined that aerobic training, unlike other exercise programs, has the greatest significant effect on changes in the structure and function of the brain, especially if certain types of cognitive thinking and a higher level of attention are needed to perform certain tasks. This suggestion should be used a guideline for future studies in this field, that is, to design an aerobic exercise program which would also include the simultaneous solution of certain cognitive tasks.

It's well known that physical exercise at the preschool age results in positive effects on motor abilities, especially: explosive strength, repetitive strength, coordination, speed, and flexibility (Dobrila et al., 2003; De Privitellio et al., 2007; Alwasif, 2013; Krneta et al., 2015; Bellows et al., 2017; Birnbaum et al., 2017). In this paper we analyzed fine motor skills, motor coordination, balance and body coordinaton. When it comes to testing fine motor skills, a significant effect of the aerobic program was noted on the fine motor skills total, which is in accordance with the systematic review which shows positive effects of different physical exercise programs on fine motor skills in preschool children (Strooband, de Rosnay, Okely, & Veldman, 2020). Although it should be pointed out that no significant effect of aerobic training was noted on the variables of fine motor integration and manual dexterity. We should point out that the development of fine motor skills has a positive effect on the sensory-motor development of the nervous system (Ivković, Milanović, Velinov, & Nikolić, 2004), which is why attention should be paid to the development of the fine motor skills of children.

On the tests of motor coordination, a significant effect of the experimental program on all the variables was noted, including: bilateral coordination, balance, and motor coordination total, which is in accordance with the existing research (De Privitellio et al., 2007; Krneta et al., 2015; Bellows et al., 2017; Birnbaum et al., 2017). Motor coordination is one of the main elements of the motor skills of children, but also their cognitive abilities and psychological characteristics (da Silva Pacheco, Gabbard, Ries, & Bobbio, 2016). The proper development of body coordination is an exceptionally important factor since it can to a great extent affect the quality of life of the child, as well as various bio-psycho-social aspects. This is why it is very important to determine any irregularities in body coordination at an early age among children, and remove them in time (Veljković, Katanić, & Ilić, 2020).

In relation to the limitations of this study, recommendations for further research would be to: include a larger sample of respondents; conduct the intervention over a longer period; include cognitive tasks in aerobic exercises; use different cognitive tests, ie tests that will measure various cognitive abilities.

CONCLUSION

The preschool age is a time of life when motion plays an important role since children are eager to constantly run, jump, and play. Realizing physical education programs for preschool children can significantly affect the improvement of their overall psycho-physical development. Thus, it is possible to affect the improvement of motor and cognitive abilities, which will enable children to realize their potential more easily. This study did not determine a positive impact of aerobic training on the cognitive abilities of preschool children. However, a significant effect of aerobic training on motor skills such as: fine motor skills total, bilateral coordination, balance, and motor coordination was noted. It should be pointed out that the given abilities are exceptionally important since they represent one of the main elements of motor, but also cognitive and psychological skills. We can conclude that aerobic training can represent an excellent means for the psycho-physical development of preschool children.

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EFEKTI DVANAESTONEDELJNOG AEROBNOG TRENINGA NA KOGNITIVNE I MOTORIČKE SPOSOBNOSTI DECE PREDŠKOLSKOG UZRASTA

Cilj ovog longitudinalnog istraživanja bio je da se utvrde efekti aerobnog treninga na kognitivne i motoričke sposobnosti dece predškolskog uzrasta. Uzorak ispitanika obuhvatio je 47-oro dece predškolskog uzrasta od pet do sedam godina. Deca pohađaju predškolsku ustanovu „Ljubica Vrebalov" u Požarevcu. Učesnici su nasumično podeljeni u dve grupe: eksperimentalnu (n=25, 6.35±0.32 godina) i kontrolnu grupu (n=22, 5.90±0.27 godina). Eksperimentalna grupa je učestvovala u aerobnom treningu za decu u periodu od 12 nedelja u trajanju od tri treninga nedeljno po 30 minuta. Za procenu kognitivnih sposobnosti dece korišćen je Test Zrelosti za Školu, tačnije tri njegova podtesta: vizuelno pamćenje, kocke za slaganje i kodovi. Za procenu njihovih motoričkih sposobnosti korišćena je baterija testova BOT-2 (Bruininks-Oseretski Test of Motor Proficienci), odnosno njeni podtestovi: fina motorička integracija, manuelna spretnost, bilateralna koordinacija i ravnoteža. Ispitanici su uradili ukupno 77 zadataka, od čega 48 kognitivnih i 29 motoričkih, kako na inicijalnom tako i na finalnom merenju. U radu se analizira ukupno 10 varijabli, četiri kognitivne i šest motoričkih, koje predstavljaju ukupne standardizovane vrednosti na osnovu pola i uzrasta za svaku od sposobnosti. Ni za jednu od varijabli kognitivnih sposobnosti nije utvrđen značajan efekat primenjenog treninga. Rezultati pokazuju da je aerobni trening imao značajan uticaj na sledeće motoričke varijable: finu motoriku (p=.020), bilateralnu koordinaciju (p=.000), motoričku ravnotežu (p=.001) i koordinaciju tela (p=. 000). Utvrđen je značajan efekat za sve četiri varijable.

Ključne reči: *aerobne vežbe, motoričke sposobnosti, kognicija, predškolski uzrast, BOT-2*

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Research article

DO STUDENTS FROM RURAL SETTINGS HAVE MORE POSITIVE ATTITUDES TOWARDS OUTDOOR ACTIVITIES?

UDC 796.5:37.013.3

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Abstract. *The main goal of the present study was to explore if there are any differences in attitudes toward outdoor activities between students from urban and rural areas. Moreover, it was necessary to extract data regarding implementation of certain models of outdoor activities in order to evaluate which models are mostly carried out as extracurricular activities in nature in order to draw valuable conclusions for future practice. The results showed that there were no significant differences between students from urban and rural settings, except in students' attitudes towards benefits of outdoor activities on proper growth and development in favor of students from rural areas. According to Cohen's interpretation, a small to moderate effect (Cohen's d=0.02-0.38) regarding living environment variations was present in the relevant items. Moreover, excursions were the most implemented extracurricular activity at schools, and regarding outdoor activities, outings and athletic cross country were the most dominant. However, outdoor activities like winter and summer outdoor activities, camping, cycling, hiking tours should be implemented in order to potentially improve students' engagement in physical activity in natural environments. Future studies should be focused on exploring the effect of diverse natural environments, PE teachers' and practitioners' competencies, school curriculums, students and parents' barriers towards outdoor physical activities. This multifactorial approach could probably provide causal relationship, which could clarify this issue.*

Key words: *Extracurricular physical activities, natural environment, urban and rural areas.*

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INTRODUCTION

McCurdy et al. (2010) came up with the interesting term of "nature-deficit disorder" to describe children's lack of outdoor activity, replaced by electronic media and a demanding school schedule. These lifestyle trends have certainly promoted physical inactivity, which could possibly impair physical and psychological health. However, a growing body of evidence has suggested that exposure to nature may directly benefit health. Physical benefits of outdoor activities are well supported in the literature. Outdoor activities provide an essential basis for the development and improvement of motor skills (Little & Wyver, 2008). Vigorous physical activity improves lung function, strengthens the heart, contributes to bone, joint, and muscle health (Bell, Wilson, & Liu, 2008). Researchers have linked a lack of outdoor time with asthma (Lovasi et al., 2008), vitamin D deficiency (Hu et al., 2017), as well as myopia (Deng & Pang, 2019). The reported effects of physical activity in natural environments were that participants had greater feelings of revitalization and positive engagement, decreases in tension, anger, depression, and confusion (Thompson Coon et al., 2011). Outdoor activities provide an environment that enhances contact with others and nature, therefore, may have a positive impacts on self-development, and building a relationship with nature (Eigenschenk et al., 2019). However, in a growing body of literature unanimous consensus regarding the benefits of outdoors activities from the aspect of potential safety issues has not yet been met. Apparently, Fuselli et al. (2012) emphasize that outdoor activities should be actively supervised in order to minimize the risk of injury. On the other hand, Tremblay et al. (2015) argue that we have become an excessively risk adverse society, that we have potentially limited crucial learning and developmental opportunities for children, that could be acquired only during outdoor activities. On the basis of the previous statement, this overprotective approach could reduce physical activity even further and increase more sedentary behaviors. Furthermore, the belief that the indoors is safer than the outdoors could however be misleading from the aspect of the potential harms of the internet (cyber-bullying, violence, and pornography), and reduced physical activity (Browne & Hamilton-Giachritsis, 2005; Burdette et al., 2004). Tremblay et al. (2015) argue that the potential risk of outdoor activities is commonly interpreted as alarming; however, exposure to risk could be essential for healthy child development. Decreasing time spent in outdoor activities should be a major concern. Outdoor activities provide crucial benefits, learning and developmental experiences that cannot be efficiently provided through indoor activities (Kemple et al., 2016). Burdette et al. (2004) emphasize that parents reported that physical activity usually occurs during outdoor playtime as opposed to during indoor activities. Moreover, to the best of our knowledge, neither of the previous studies has found outdoor time to be associated with decreased physical activity.

From a living environment standpoint, it is possible that increased physical activity is associated with vegetation-rich living environments. For example, urban vegetation might influence children and youth, and could provide more opportunities for engagement in outdoor physical activity due to a wider variety of open spaces (parks, school yards, bicycle tracks, etc.) (Bell et al., 2008). Parks, school yards, trails, and other open spaces provide surroundings that can stimulate physical activity. It is important to note that positive attitudes toward lifelong physical activity are developed in early childhood (Tammelin et al., 2014). However, due to increasing urbanization and population density, many people live in urban areas lacking vegetation, parks, and other natural environments, limiting the availability of accessible and safe outdoor activities for children (McCurdy et al., 2010). Therefore, it could be assumed that children from rural settings have more

opportunities to engage in outdoor activities, and consequently have more positive attitudes toward them. However, contemporary pandemic conditions have certainly reduced outdoor physical activity in children, and possibly influenced more sedentary behavior (Vuković et al., 2021). Moreover, Zenic et al. (2020) point out that there was an significant reduction in children's physical activity during the pandemic caused by the Covid-19 virus, especially from urban areas. Similar to physical activity engagement, the parental environmental circumstances could influence the total amount of electronic device time a child is consuming. For example, a full-time parent living in a rural environment is potentially more able to engage their child in outdoor physical activities than a full-time working single parent living in a small apartment in an urban environment (Bates et al., 2020). Furthermore, schools from urban and rural settings could potentially have vastly different opportunities to implement different models of outdoor activities (hiking tours, outings, winter and summer outdoor activities, athletic cross-country, etc.). Existing problems regarding open space availability could potentially limit schools from urban areas to implement certain extracurricular contents in nature, especially in contemporary pandemic conditions. We should emphasize, that schools are potentially very valuable institutions when it comes to promoting physical activity (Bailey, 2006).

Therefore, the main goal of the present study was to explore if there are any differences in attitudes toward outdoor activities between students from urban and rural areas. Moreover, it was necessary to extract data regarding implementation of certain models of outdoor activities in order to evaluate which models are mostly carried out as extracurricular activities in nature in order to draw valuable conclusions for future practice.

MATERIALS AND METHODS

Study design and Procedures

This cross-sectional study was conducted during first semester in October 2021. The study included 8th grade students and employed a self-reported questionnaire assessing attitudes towards outdoor activities. The completion of the questionnaire was not limited by time. To ensure the complete honesty of the self-reported attitudes towards outdoor activities, respondents were informed that their answers would remain anonymous, and the results would be used only for research purposes. Incompletely administered responses with an ambiguous outcome were not included in the further analysis. 141 responses out of 143 met the inclusion criteria for further analysis. The questionnaire was preceded by sociodemographic questions. Therefore, it was possible to examine possible differences between different categories (urban vs rural students). The procedures in this study were conducted according to the Declaration of Helsinki as the statement of ethical principle for research involving human subjects.

Participants

The sample was comprised of a total of 141 eighth-grade students, 64 (45.4%) of which were males, and 77 (54.6%) females. Furthermore, 71 (50.4%) of the respondents were form urban, and 70 (49.6%) from rural surroundings. During the testing procedure, the respondents were fully acquainted with the research procedure and informed that they could withdraw from the study at any time.

Measures

The Attitudes toward outdoor activities questionnaire (ATOAQ). A newly constructed ATOAQ inventory was used in the present study. The ATOAQ assesses students' attitudes towards outdoor activities. This questionnaire is composed of 8 items, where 3 items *("Do you like to spend more time in nature", "Do you like to walk during the day?", "Do you like to engage in outdoor activities at your school")* represent individuals' motivation to engage in outdoor activities (items M1-M3), and the other 5 items *("Do outdoor activities affect the proper growth and development", "Do outdoor activities develop a collective spirit?", "Do outdoor activities develop discipline and responsibility?", "Do outdoor activities reduce peer violence?",* and *"Do outdoor activities provide new knowledge and have application in daily life?")* represent individuals' opinion on the benefits of outdoor activities (items O1-O5). Statements were evaluated using a three-point Likert scale. The response options for each question were as follows: 1) No; 2) Partially; and 3) Yes. Apart from individual item analysis, relevant items for each variable were summed to form composite scores included in the comparative analysis (urban vs rural students). For example, the outdoor activities benefits scale score was formed by summing the scores of the relevant items (No = 1; Partially = 2; Yes = 3).

We were able to extract two distinct factors using the explorative factor analysis (EFA). The principal component factor analysis using direct oblimin rotation method proved that each item corresponds to theoretically assumed factors. Item communalities (median = .57; range .45–.68) were over 0.40, which indicate that each item is related to the other items on the scale, and suggest that two factors are appropriate for the present inventory. Factor loadings for this scale were clear, with moderate to high factor loadings (ranging from .53 to .82, and .57 to .88 on the two factors) and minimal cross-factor loadings, except from items 3 and 7 (.31 and .27). The KMO was 0.81.

Moreover, it was necessary to evaluate the fit of the model for the scale. The results of the confirmatory factor analysis (CFA) indicated a good fit (SRMR = .047; CFI = 0.949, RMSEA = .074) (see Fig. 1). The internal consistency in this study for the scale proved to be good (0.80).

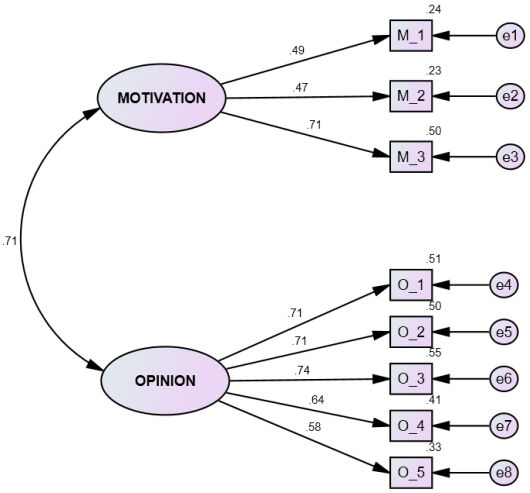

Fig. 1 Confirmatory factor analysis (CFA)

Data analysis

All data analyses were carried out using SPSS (IBM SPSS, version 23.0; IBM SPSS, Armonk, NY, United States). Descriptive statistics were computed for all sociodemographic and study variables. Means, medians, standard deviations, frequencies, and percentages where appropriate were computed to describe both categorical and continuous variables for the total sample. The exploratory factor analysis was performed to reduce data to distinct factors which could explore the underlining theoretical structure of the construct. The confirmatory factor analysis (CFA) was performed to evaluate the fit of the newly constructed scale. Since the assumption of normal distribution was violated, the Mann-Whitney U test was performed to assess the differences between distinct subsamples (urban vs rural students) in both individual items and the overall scale score. Cohen's d analyses were performed to evaluate the effect size. Significance was set at the 0.05 level.

RESULTS

The sample demographic characteristics and outdoor specific data are presented in Table 1. It should be noted that outdoor specific data were extracted from the multiple response analysis, therefore, one respondent could choose more than one response. Excursions were the most present extracurricular activity at the schools. Moreover, from the aspect of outdoor activities organized within the regular school curriculum, outings and athletic cross country were the most dominant ones.

Table 1 Summary of demographic and outdoor activity specific data (frequencies and percentages)

	n (%)	
Gender		
Male	64	(45.4)
Female	77	(54.6)
Living environment		
Urban	71	(50.4)
Rural	70	(49.6)
Extracurricular activities at the schools		
Excursions	114	(80.9)
School in nature	40	(28.4)
Recreational classes	19	(13.5)
None	17	(12.1)
Outdoor Activities at the schools		
Winter outdoor activities	10	(7.1)
Summer outdoor activities	7	(5.0)
Outings	90	(63.8)
Athletic Cross Country	60	(42.6)
Hiking tours	11	(7.8)
None	17	(12.1)
Students needs for outdoor activities		
Winter outdoor activities	37	(26.2)
Summer outdoor activities	52	(36.9)
Outings	38	(27.0)
Cycling	35	(24.8)
Hiking tours	12	(8.5)
Camping	57	(40.4)

The differences between students from urban and rural settings are presented in Table 2. Since the Kolmogorov-Smirnov test was significant for all the continuous variables, non-parametric statistical procedures were applied. Living environment variation showed significant differences among distinct groups only in the item *"Do outdoor activities affect the proper growth and development"*, where students from rural settings presented significantly higher scores. According to Cohen's interpretation, small to moderate effects regarding living environment variations were present in the relevant items.

Table 2 Differences between students from urban and rural settings, Independent Samples Mann-Whitney U test

Item	Mann-Whitney U	Z	Cohens` d	P
Do you like to spend more time in nature?	2395.5	-.517	0.06	.605
Do you like to walk during the day?	2124.5	-1.750	0.25	.080
Do you like to engage in outdoor activities at your school?	2438.5	-.246	0.03	.806
Do outdoor activities affect the proper growth and development?	1933.0	-2.603	0.39	.009
Do outdoor activities develop a collective spirit?	2367.0	-.569	0.08	.569
Do outdoor activities develop discipline and responsibility?	2304.5	-.838	0.13	.402
Do outdoor activities reduce peer violence?	2467.5	-.078	0.01	.938
Do outdoor activities provide new knowledge and have application in daily life?	2413.5	-.352	0.05	.725
Overall Score	2452.0	-.137	0.02	.891

Note. Mann-Whitney U – value of Mann-Whitney U test;
Z – z score; Cohens` d – effect size; P – p value

The graphical representation of average values of the relevant items for students from urban and rural settings can be seen in Fig. 2. Students' attitudes toward outdoor activities were mostly positive; however, it should be noted that negative attitudes were also present. For example, the relevant item "Do outdoor activities reduce peer violence" proved to have more than 40% negative responses, among both urban and rural students.

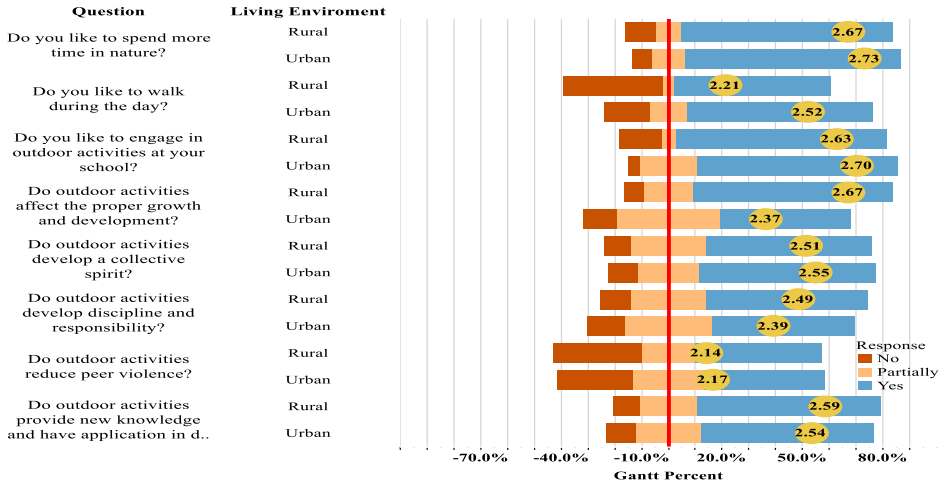

Fig. 2 Graphical representation of average response values for students from urban and rural settings. A red vertical reference line separates positive and negative responses.

DISCUSSION

The main goal of the present study was to explore if there are any differences in attitudes toward outdoor activities between students from urban and rural settings. The initial assumption was that students from rural settings could potentially have more positive attitudes towards outdoor activities due to the availability of more natural environment surroundings and lower residential density. Bell et al. (2008) emphasize that there is a positive relationship between neighborhood greenness and residential density and physical activity, where open spaces could promote increased time spent in outdoor activities. Moreover, the abovementioned authors argue that outdoor spaces with vegetation are more likely to stimulate physical activity than outdoor spaces without vegetation. Looking back on the previous statement, students from rural settings should have significantly higher scores regarding attitudes toward outdoor activities. However, the results of our study failed to confirm the initial assumption. Based on our results, there was no significant difference among the surveyed populations, except in the items created to explore attitudes towards benefits of outdoor activities on proper growth and development, in favor of respondents from rural areas. It has been shown that physical activity improves children's health, and a growing body of evidence suggests that exposure to natural environments could decrease stress and improve attention in children (McCurdy et al., 2010). From a practitioner's standpoint, outdoor activities provide significant physical and mental health benefits that often go beyond the benefits of indoor physical activity (Eigenschenk et al., 2019). Research has demonstrated that outdoor activities, especially in natural environments, have significant potential to benefit children's cognitive, emotional, social, and physical development, as well as their health and overall well-being, self-regulation skills, and attention (Kemple et al., 2016). The study conducted by Fjørtoft (2001) indicates that the there is a positive relation between outdoor activities in the natural environment and motor fitness in children. Authors argue that motor competences are of great importance to children's general adaptation to the physical environment. Apparently, there is a strong relation between the natural environment and outdoor play, which could be physically and psychologically beneficial. However, although studies have proved the various benefits of outdoor activities in natural environments, many playgrounds in early childhood do not entirely encourage children's interaction with nature. Furthermore, childhood educators are often unaware of the importance of outdoor activities and children's interactions with nature (Kemple et al., 2016). This could potentially explain the results of our study, meaning that natural surroundings, although beneficial, without systematic planning and early childhood engagement in natural settings could not alter attitudes toward outdoor activities. Therefore, PE teachers should provide the opportunity for highly efficient models of outdoor activities in natural environments, especially during school hours. Teachers' knowledge and attitudes on importance of outdoor play activities are essential. It should be noted that schools as educational institutions are the most important environment for the promotion of the physical activity of students. Physical education and school sports, in addition to directly affecting the development of motor skills, primarily enable increased physical activity of children during physical education classes and extracurricular school activities (Bailey, 2006). For example, Davies (1997) found a relationship between teachers' behavior and teachers' self-reported beliefs about their role as an educator during outdoor activities, and suggested that there is a need for professional development of teachers, which would emphasize the positive effects of

outdoor activities and how to overcome eventual barriers which could limit implementation of such contents. Authors Burdette et al. (2004) measured outdoor time and physical activity in children by direct observation, and the evidence suggests that higher physical activity levels occur during prolonged outdoor staying in comparison to indoor. In a context of school curriculum, outdoor extracurricular activities in Serbia are described as very valuable for the development children and adolescents. However, the results from the multiple response analysis in our study suggest that outings (63.8%) and athletic cross-country (42.6%) are the most implemented models of outdoor activities, while winter outdoor activities (7.1%), summer outdoor activities (5.0%), and hiking tours (7.8%) are implemented to a much lesser extent. The possible explanation for this unequal distribution could be found in the complexity of the content of summer and winter activities, and hiking tours which would require a longer stay in a particular destination, which implies greater organization and greater responsibility of the schools and PE teachers. In addition, it is important to note that outdoor activities could carry potential risk, which could explain the reduced involvement of schools and PE teachers in organizing such activities, especially in a situation of restrictive measures during a pandemic. Fuselli et al. (2012) emphasize that outdoor activities should be accompanied with active supervision, teaching about safety rules, and remind children how to use equipment safely, check local area equipment and surfacing, etc. Yet, Tremblay et al. (2015) argue that recent decades have shown an increasing trend toward greater monitoring and restrictions on child play. Consequently, half of Canadian children actively play outdoors only 3 hours per week. While safety issues should be addressed, avoiding all risk is not a good solution, as doing so we could create a potential limit in children's participation in such activities that promote their optimal development and health. As Little and Wyver (2008) argue, the ultimate goal for parents and PE teachers should be to provide outdoor activity environments and models where the risks of serious injury are reduced, but creativity, challenge, and excitement are preserved. However, the results of our study cannot confirm these statements, therefore future research should examine this issue in more detail. Nonetheless, outdoor activities should be utilized in regular curricular and extracurricular programs including sustainable development of education process. Eigenschenk et al. (2019) argue that investments in outdoor activities are estimated as being very cost-effective, as many positive effects could be provided without significant infrastructure investments (nature provides more than enough). However, based on our results, excursions (80.9%) were the most dominant extracurricular activities at schools, followed by school in nature (28.4%), and recreational classes (13.5%) (see Table 1). We should note that excursions are facultative extracurricular activities, which are mostly organized only once per year in Serbia. Therefore, it is rather questionable whether this particular model could permanently improve students` attitudes towards outdoor activities; therefore more extended outdoor activities program may be warranted. The worrying fact however is that activities like school in nature and recreational classes, which could promote the benefits of outdoor activities, were much less implemented. This could be an important finding, and future studies should explore the effects of an extended outdoor activities program on students' attitudes in more depth. Actually, based on the results of our study, we can observe that the students' needs for a wider range of activities in the natural environment are very well represented. For example, students expressed a need for different models of outdoor activities such as winter (26.2%) and summer (36.9%) activities, outings (27.0%), cycling (24.8%), camping (40.4%), and hiking tours (8.5%) (see Table 1). In fact, it is quite plausible that more content rich

programs, as well as more frequent engagement in such activities can contribute to the development of more positive attitudes towards them. We can support the previous claim with the research that emphasizes that a more content rich extracurricular program in school provides students with the opportunity to engage in activities of their choice, which could develop overall satisfaction with friends, family, and school, and develop positive attitudes (Gilman, 2001).

Furthermore, our results showed that more than 40% percent of the respondents (both urban and rural) had negative attitudes toward the benefits of outdoor activities on peer violence (see Fig. 1). These results are not entirely surprising, giving the fact that contemporary circumstances regarding the pandemic may reduce the implementation of potentially beneficial models like winter and summer outdoor activities, and hiking tours. Therefore, it is possible that reduced participation in the number of outdoor activities could influence the overall attitudes of students. Physical contact restrictions during the pandemic caused by the COVID-19 virus, including distance learning strategies, reduced engagement in physical activity, sports, and other models of school-related organized outdoor physical activity. Bates et al. (2020) argue that school and parental strategies to increase physical activity should be directed toward implementing contents that promote outdoor activities. However, these authors also emphasize that there are some possible difficulties in conducting such activities, due to specific work schedules during pandemic restrictions. Although the recommendations for the regular physical activity of children basically refer to normal circumstances, the limited opportunities to engage in outdoor activities could develop inactive lifestyle habits in Serbian school children (Vuković et al., 2021). Furthermore, physical activity levels before the onset of the pandemic caused by the COVID-19 virus suggested that Croatian adolescents were not meeting physical activity recommendations due to COVID-19 restrictions, and that individuals living in urban environments were experiencing a greater decrease in physical activity levels than in rural environments (Zenic et al., 2020). Schmidt et al. (2020) found that sports activity declined whereas recreational screen time increased. Therefore, it is plausible that increased screen time could potentially reduce time spent in natural environments as well. Moreover, there is evidence that violent screen content has significant short-term effect on altering aggressive behavior (Browne & Hamilton-Giachritsis, 2005). It should be noted that the presence of vegetation during outdoor activities may impact physical activity. In fact, boys may feel more relaxed and therefore better able to interact productively in this greener area of their playground (Kemple et al., 2016). Moore and Wong (1997) found that when an asphalt play area is transformed into a more natural area, children's social behavior could change, which could influence less aggressive behavior. Although we could assume that reduced outdoor physical activity and increased screen time could have impacted attitudes towards peer violence during the period of data collection for the present study, our result cannot support this statement.

In future practice students should be offered more than a few effective models of outdoor activities in order to provide the potential to develop a connection with nature as an important foundation for the development of an environmental codex and commitment to the preservation of nature (Kemple et al., 2016). We found some evidence from a previous study that physical activity in an outdoor natural environment could provide more beneficial positive effects on mental wellbeing than in an indoor environment. The natural environment includes many different types of green space such as wilderness areas, urban parks, open countryside, country parks, woodlands, and wildlife reserves.

However, the influence of different type of green space as a moderator on overall physical activity should be clarified in future studies (Thompson Coon et al., 2011).

Finally, from the aspect of differences between students in urban and rural areas, the present study cannot explain the cause-and-effect relationship. It is quite possible that the available natural environment in rural areas is not a sufficient stimulus for students` active engagement in outdoor activities, and therefore the development of more positive habits and attitudes towards them could not be met, at least not significantly. Future research should examine the immediate activity of students in outdoor activities, as well as outdoor space availability for implementing different contents in urban and rural areas. Moreover, it is necessary to investigate the activity of PE teachers and other practitioners in the affirmation and promotion of contents that encourage physical activity in a natural environment.

CONCLUSION

The main goal of the present study was to explore whether any differences regarding attitudes towards outdoor activities were present between students from urban and rural settings. The initial assumption was that rural students would have significantly more developed positive attitudes due to a potentially more favorable natural environment to engage in outdoor activities. However, results from our study could not support such a hypothesis, meaning that the natural environment alone could not substantially influence improvements in attitudes towards outdoor activities. In addition, we should note that outdoor activities like occasional outings and athletic cross-country may be insufficient to develop positive attitudes; therefore, additional activities like winter and summer outdoor activities, camping, cycling, and hiking tours may be warranted. It is quite plausible that an extended number of extracurricular activities and more frequent implementation of such models could improve students' engagement and their attitudes towards outdoor activities. However, our results could not fully explain the current issue and provide solid evidence; therefore, future studies should investigate this matter in more depth. For example, future studies should be focused on exploring the effect of diverse natural environments, PE teachers' and practitioners' competencies, school curriculums, and students and parents' barriers towards outdoor physical activities. This multifactorial approach could probably provide a causal relationship which could clarify this issue.

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DA LI UČENICI IZ RURALNIH SREDINA IMAJU POZITIVNE STAVOVE PREMA AKTIVNOSTIMA U PRIRODI?

Osnovni cilj ove studije bio je da se istraži da li postoje razlike u stavovima prema aktivnostima u prirodi između učenika iz urbanih i ruralnih sredina. Takođe, bilo je potrebno izdvojiti podatke o implementaciji određenih modela aktivnosti u prirodi kako bi se uvidelo koji se modeli uglavnom sprovode kao vannastavne aktivnosti u prirodi, radi donošenja korisnih zaključaka za buduću praksu. Rezultati su pokazali da nije bilo značajnih razlika između učenika iz urbanih i ruralnih sredina, osim u stavovima učenika prema benefitima aktivnosti u prirodi na pravilan rast i razvoj, u korist učenika iz ruralnih sredina. Prema Cohenovom tumačenju, mali do umereni efekat (Cohen's d=0,02-0,38) u pogledu životne sredine bio je prisutan u relevantnim stavkama. Štaviše, ekskurzije su za većinu učenika bile najčešće organizovana vannastavna aktivnost u školama, a kada su u pitanju aktivnosti u prirodi, najdominantniji su izleti i atletski kros. Međutim, aktivnosti u prirodi kao što su zimske i letnje aktivnosti na otvorenom, kampovanje, biciklizam, pešačke ture bi trebalo učestalije da se realizuju u cilju povećanog angažovanja učenika u fizičkoj aktivnosti u prirodnom okruženju. Buduće studije bi trebalo da budu fokusirane na istraživanje efekata različitih prirodnih okruženja, kompetencije nastavnika fizičkog vaspitanja i ostalih edukatora, školskih programa, barijera učenika i roditelja prema aktivnostima u prirodi. Ovaj multifaktorski pristup bi verovatno mogao bliže da objasni uzročno-posledične veze, u cilju rasvetljavanja ovog problema.

Ključne reči: *vannastavne fizičke aktivnosti, prirodno okruženje, urbane i ruralne sredine*

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Research article

STANDARDIZED PLANNED AGILITY TESTS IN YOUNG FOOTBALL PLAYERS: MATHEMATICAL MODELING IN THE FUNCTION OF DEFINING PHYSICAL POTENTIAL

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Abstract. *Each process of efficient management of an athlete's condition entails proper diagnostics, prognostics, and modelling by measuring gathered information. This study aims to come up with a standardized mathematical model for assessing the physical condition of young football players in relation to planned and programmed agility. This study implemented the mathematical modelling method for the general profiling of the evaluated motor capacity, in order to obtain a tool for classifying the condition of an individual in relation to the population standard. This study applied planned and pre-programmed motion patterns to test the capacity of planned agility using six variables: 3 original and 3 calculated. All the original variables underwent mathematical transformation in relation to the multiscale modelling of Z-distribution, so that all the results have been transformed into an analogous result in the range between 0, as the distribution minimum, and 100, as the distribution maximum. This produced analogous quantitative, i.e. numerical values of the score, i.e. the distributive position of each result in relation to the tested age group. The defined mathematical models for the prediction of the level of development of the measured agility type do not only have absolute, but also hypothetical potential for determining the relative position of each young player in relation to their age population. The proposed models have strength at the level of absolute explained common variance (Adj R^2 = 1.000, i.e. 100.0% of the explanation) with a marginal standard error of prediction (only 0.003 points). Processing diagnosed information in such a way makes it possible to precisely define the initial, transit, and final condition of the athlete, programming an efficient, optimized and quality training process, as well as proper identification of talents in selecting young athletes.*

Key words: *diagnostics, planned agility, modelling, prediction, standardization.*

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1. INTRODUCTION

In team sports, one of the important characteristics for success greatly depends on the athletes' abilities to shift their bodies (transposition) or individual limbs (translocation) in relation to the space around them, as quickly as possible when changing direction of movement in a specific competitive situation (Sarmento et al., 2018). The speed of change of direction (COD) is especially dominant in team sports , or in other words, the ability to accelerate and decelerate and change direction while maintaining good control of the movement of one's body or its segments while maintaining speed (Baechle, 1994; Draper & Lancaster, 1985), or the ability to change direction rapidly (Brown & Ferrigno, 2005; Drabik, 1996), efficiently carry out stop-and-go motion (Flisk, 2000), change the direction of movement without losing balance, speed, power and control (Pearson, 2001), change of direction in relation to quick and accurate action in space and time (Gabbet & Sheppard, 2013), etc. However, it was recognized some time ago that no prior definition of this ability had taken into account the perceptual components and decision-making components which are involved in executing basic movements present in the competitive structure of most sports. Later research on this ability created a clear discrepancy and definitively introduced the term agility, which defines the ability comprising components of change of direction and components of perception and decision-making, since change of direction and speed is often carried out in response to the opponent's action (Rigg & Reilly, 1988; Young et al., 2002). Because of its complex structure and cognitive demands, agility is considered an isolated motor capacity (Jeffreys, 2006), an open motor skill which requires athletes to respond to the surrounding sensory stimuli, while their response is not involuntary (Cox, 2002). So, according to current theory (Pajić, 2017), the accepted conceptual model of agility is accepted, but instead of the terms "agility" and "speed of change of direction", the terms "reactive/random agility" and "planned agility" are used (Oliver & Meyers, 2009), as well as programmed agility (familiar movement conditions) and randomized agility (unknown movement conditions) (Person, 2001; Scarlan et al., 2021). In tests of carrying out planned agility, participants were introduced to the required movement pattern beforehand, while for reactive agility the direction changed in response to stimuli applied during the test.

Efficiency of every motor task primarily depends on the influence of coordination factors such as accuracy in relation to the complexity of the task, space, time, and intensity of the exerted force. For this reason, the study presupposes that each engaged age group will successfully and efficiently carry out the planned agility tests assigned to them, without a negative impact from any of these transfer factors.

During adolescence, almost all young players go through significant variations in growth (body size) and development (biological maturity) which can impede the prediction of their future performance (Figueiredo et al., 2011; Malina et al., 2004; Malina et al., 2004). It is therefore necessary to continually model possible relations between the kind of offered information regarding the carried out measurements, and form evaluation criteria which would be accurate and usable for their training. This allows for quality feedback, which is a necessary condition for optimizing and controlling the effects of the modern-day training processes. An optimized process of preparation in sports requires constant evaluation of the effects of training by applying suitable diagnostic procedures and consequently suitable modelling of the obtained information. The obtained results and their proper interpretation allow for ascertaining the advantages

and disadvantages of athletes' physical condition, as well as setting realistic goals and tasks of the training process in programming individual training.

Athletic training entails a controlled multi-year process with systematic application of various training methods and motor workload on athletes of various ages (Malina et al., 2004). During a given multi-year training process, the methods applied in controlling the physical condition of the athlete must be as responsive and specific as possible, but also individually sensitive, both in recognizing the effects of the applied training models and in recognizing the specific talents of an individual, i.e. the level of their motor potential as an important part of sporting talent (Nikolaidis et al., 2012; Dopsaj et al., 2019; Lima-Souza et al., 2020; Majstorović et al., 2020). For all of the above, and for efficient control of long-term athlete development, it is necessary to develop reliable procedures which would make it possible to monitor the development of an athlete in relation to motor capacities which are significant to the individual's sport. A significant scientific method is the mathematical modelling method for the general profiling of a given motor capacity, in order to obtain a tool for classifying the condition of an individual in relation to the population standard (Majstorović et al., 2020; Dopsaj et al., 2010; Zatsiorsky, 1982).

This study aims to come up with a standardized mathematical model for assessing the physical condition of young football players in relation to planned and programmed agility, which would be applicable to the long-term control of the development of a young athlete.

2. MATERIALS AND METHODS

This study applied planned and pre-programmed motion patterns to test the ability of planned agility. They were selected in such a way that their temporal, spatial and intensity organization were age-appropriate for the participants. This presupposes the elementary reliability of these tests, with the avoidance of any possible negative transfer. The organization of the tests allows the evaluation of planned agility (speed of change of direction) because they provide: biomechanical specificity (kinetic and kinematic congruence), mode specificity (congruence of mode in generating muscular force occurs in that mode of muscular operation in which the evaluated speed of change of direction occurs), muscle adaptation specificity (congruence of the engaged musculature – inter-muscle coordination), and metabolic specificity (congruence and high correlation with energy requirements of the chosen tests, taking into account the age of the participants).

1.1. Participants

The sample of participants comprised 960 male participants, divided into three groups according to their chronological age: 320 boys of age 8.5 ± 0.4 years, body high - BH = 132.0 ± 0.06 m, body mass - BM = 28.7 ± 4.60 kg, body mass index - BMI = 16.4 ± 1.83 $kg \bullet m^{-2}$; 320 boys of age 11.6 ± 0.4 years, BH = 162.5 ± 0.05 m, BM = 37.5 ± 6.70 kg, BMI = 17.4 ± 2.17 $kg \bullet m^{-2}$; and 320 boys of age 15.5 ± 0.4 years, BH = 173.0 ± 0.08 m, BM = 60.9 ± 9.80 kg, BMI = 20.1 ± 2.49 $kg \bullet m^{-2}$. All the participants had regularly taken part in football training processes for 3-8 years. The research was carried out in accordance with ethical approval number 484-2 of the ethical board of the Faculty of Sport and Physical Education, University of Belgrade.

1.2. Testing Procedure

All testing was carried out in accordance with previously described standard procedures (Gabbet, & Sheppard, 2013). To measure time, the study used a photocell timing system (Brower Timing Systems) with 0.001 s measurement accuracy. The first age group (8-year-olds) was tested using the *505 agility test*, the second (11-year-olds) using the zig-zag *Envelope test*, and the third (15-year-olds) using the *Illinois test.* Figure 1 shows all three tests of planned agility of motion.

Measurements were taken on an indoor synthetic grass pitch from 9 to 12 in the morning. Before submitting to the tests according to their age groups, the participants carried out two sets of warm-up exercises. The first set (a basic functional 10-minute warm-up) comprised a 6-minute steady state run, mobility exercises for the spinal column, especially for the legs, and the most important exercises from dynamic warm-up protocols. The second set (a specific 10-minute warm-up) was aimed at increasing neuromuscular activation and comprised coordination exercises which are suitable to the age group in their temporal, spatial and intensity organization, as well as to the complexity and structure of the tests applied in this study.

Prior to the testing, the participants were advised to follow a suitable diet, without consuming too much spicy, salty, sweet, or greasy food, or any beverages that contain caffeine or sugar for at least 2.5 hours before the test. The coaches were also informed to avoid any energy-intensive activities of motor training 48 hours before the test.

505 Agility Test

The *505 Agility Test* (Figure 1a) is of very short duration (alactate intensity), and it completely removes the occurrence of anaerobic fatigue, while measuring pure capacity of short sprints with change of direction (Draper & Lancaster, 1985; Gabbet, & Sheppard, 2013; Reaburn et al., 2011). The participants were given a task to travel a 15 m distance between two markers. The photocell system was set at the ten-meter distance. The participants were required to accelerate fully from the start line to the photocell line (10 m), stop behind the second marker, make a 180° turn, and again run with full acceleration to the finish line (5 m). The total distance travelled in this task is 20 meters.

Zig-zag test (Envelope test)

The *Envelope test* (Figure 1b) is more complex and somewhat longer planned agility test, of a relatively short duration (ATP + CP energy system), and minimizes the occurrence of anaerobic fatigue. The participants were given a task to travel the distance between five markers placed in a 3x5 m rectangle (Jones et al., 2009; Little & Williams, 2006). One photocell system was set at the start, and at the same time the finish. The participants were asked to accelerate fully from the start line along the rectangle, decelerate, properly change direction, and then accelerate to full speed to the finish line. The total distance travelled in this task is around 20 meters.

Illinois test

The *Illinois test* (Figure 1c) is a significantly complex and long planned agility test. The test completely covers the energy system capacity (ATP + CP), but it is possible that young or less fit athletes exhibit an increased significance of the anaerobic glycolytic

energy support to the ATP resynthesis, with a significant occurrence of acidic metabolites. It can be assumed that in such a situation, negative transfer may be intensified from the aspect of metabolic congruence, which brings into question the validity of the planned agility measurements, with an increased significance of lactate intensity (Pajić, 2017; Hachana et al., 2013; Raya et al., 2013). It can therefore be assumed that it is not sufficiently advisable for participants under the age of 15. The participants were given a task to travel the distance between markers in a very specifically arranged course in the shortest possible time. Two photocell systems were set, at the start and at the finish. The participants were asked to accelerate fully from the start line along the course, decelerate, properly change direction, and then accelerate to full speed to the finish line. The total distance travelled in this task is around 65 meters.

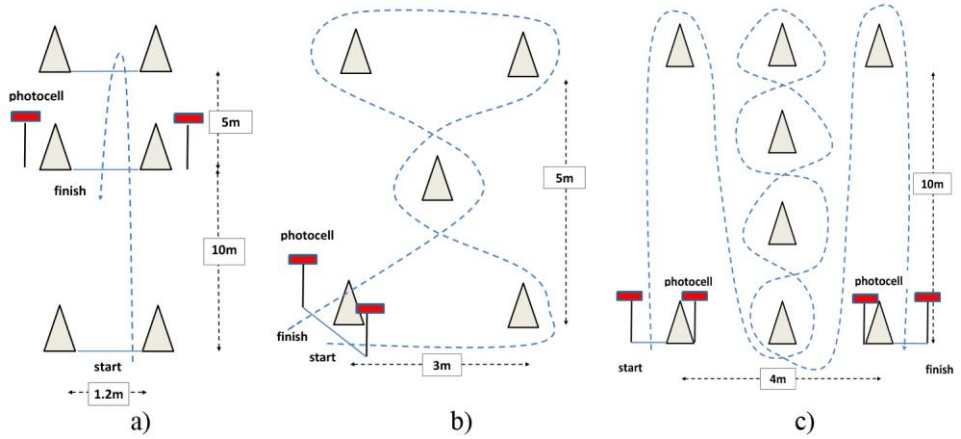

Fig. 1 The motion of the participants during the planned agility tests: a) during the 505 Running test, b) during the Envelope test, and c) during the Illinois test.

Before the measurement, the participants were given one trial attempt, and then they ran according to the provided protocol. For each individual test three measurements were made for the *505 Agility test* and *Envelope test*, and two measurements for the *Illinois test*. The best times were used in the analysis . Unlike the previous two tests, where the participants carried out three test attempts, the Illinois test was carried out only two times in each group, perhaps because a third attempt in this test, which activates the anaerobic alactate-lactate mechanism of energetic transformations for the resynthesis of ATP, might have caused significant fatigue, which in turn might compromise the reliability of the application of the test for the observed age group. The rest periods in between individual attempts were 1:20 or 1.5 minutes for the *505 Agility test*, 1:15 or 2 minutes for the *Envelope test*, and 1:10 or 3.5 minutes for the *Illinois test*, which is in line with protocols exploring movement whose structure is dominated by speed of execution (Pajić, 2017).

1.3. Statistical analysis

All the data were analysed using descriptive statistical procedures for calculating basic measures of central tendency (M), dispersion (SD), homogeneity – variation coefficient

(cV%), minimal and maximal values (Min and Max) and variable range. The distribution form was described using the skewness and kurtosis coefficient, while the normality of the result distribution was determined by applying the Kolmogorov–Smirnov nonparametric test. Percentile distribution was used to define five intervals of the normative value levels (five separate classes), including the position of each individual result expressed as a score (Zatsiorsky, 1982; Yanci et al., 2017). A linear regression was used to define the prediction equation for the achieved results of testing planned agility in the function of distribution, i.e. the distribution value, as a measure of actual motor potential of planned agility in relation to the tested age group (Hair et al., 2014).

All the original variables underwent mathematical transformation in relation to the multiscale modelling of Z-distribution (Lima-Souza et al., 2020), so that all the results were transformed into an analogous result in the range between 0 and 100 (Dopsaj et al., 2010). This produced analogous quantitative, i.e. numerical values of the score, i.e. the distributive position of each result in relation to the tested age group, which made it possible to proportionately compare individuals from the same age group in the sense of their position from the aspect of the result distribution. It also provided for a realistic comparison of an individual's position in relation to the other age groups as well (Dopsaj et al., 2019; Majstorović et al., 2020).

All of the analyses were carried out using the IBM SPSS v23.0 statistics software, while the statistical difference was set at 95% with a level of significance of $p \leq 0.05$ (Hair et al., 2014).

3. RESULTS

Table 1 represents the basic descriptive indicators of the tested variables. Table 2 represents the percentile distribution of the test results for planned agility for original and standardized variables. The given data were also defined in relation to the cut-off values of the distribution normative standards which can be used in assessing the development of the measured capacity for the purpose of the test. Further, as a function of age, the defined norms can be used in the sense of recognizing motor potential in initial diagnostics for the purposes of talent detection in football.

Table 1 Basic descriptive data on the variability of all planned agility tests

	Running Agility tests (sec.)			Running Agility score (score number)		
	505	Env	Illinois	Score_505	Score_Env	Score_Illinois
M	3.129	7.701	17.824	50.000	50.000	50.000
SD	0.232	0.420	993	16.670	16.670	16.670
cV (%)	7.41	5.450	5.57	33.340	33.340	33.340
Std. Meas. Err.	0.013	0.023	0.055	0.932	0.932	0.932
Std. Meas. Err. (%)	0.410	0.300	0.31	1.860	1.860	1.860
Min	2.29	6.580	15.41	7.570	-19.790	19.000
Max	3.72	9.460	19.67	110.220	94.500	90.520
Range	1.43	2.880	4.26	102.650	114.290	71.520
Skewness	-0.279	0.475	-0.084	0.280	-0.475	0.084
Kurtosis	1.276	0.894	-1.111	1.227	0.894	-1.111
K-S Z	0.057	0.039	0.108			
p value	0.200	0.200	0.000			

Table 2 Percentile distribution of the planned agility test results for original and standardized variables in accordance to the subsample

Percentiles	Classes	Running Agility tests (sec.)			Running Agility score (score number)		
		505	Env	Illinois	Score_505	Score_Env	Score_Illinois
97.5	Good (5)	2.77	6.94	16.06	75.76	80.19	79.60
95		2.78	7.08	16.26	75.16	74.65	76.22
90	Above Average	2.86	7.21	16.51	69.30	69.49	72.03
70	(4)	3.03	7.49	17.18	57.10	58.38	60.87
60		3.07	7.58	17.29	54.23	54.65	58.99
50	Average (3)	3.12	7.68	17.82	50.64	50.65	50.06
40		3.16	7.79	18.12	47.77	46.48	45.09
30	Below Average	3.23	7.90	18.56	42.74	42.23	37.63
10	(2)	3.49	8.21	19.19	24.08	29.85	27.06
5	Bad (1)	3.52	8.42	19.26	21.93	21.54	25.88
2.5		3.55	8.70	19.32	19.77	10.47	24.87

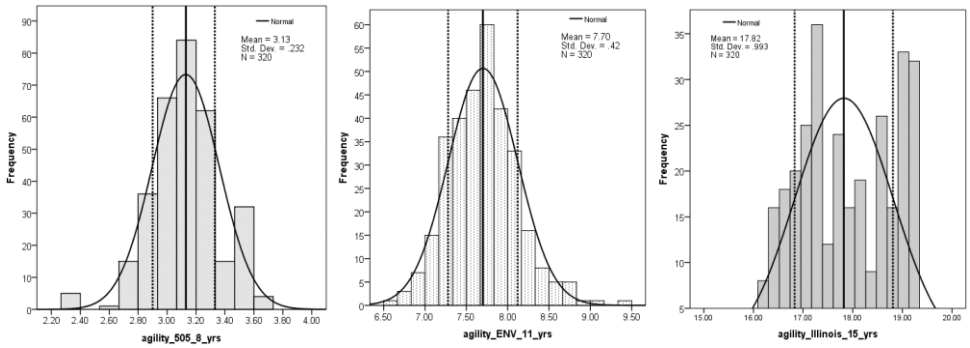

Fig. 2 Frequency distribution graphs for all three running agility tests

Based on the results of the distribution regularity obtained by applying the K-S test, it is clear that the distribution in the age groups of 8 and 11 does not statistically significantly deviate from the hypothetical normality (Table 1, *505 Agility test* and *Envelope test*, p = 0.200, Figure 2). However, the result distribution for the third test is statistically significantly different from the hypothetically regular one (Table 1, *Illinois test*, p = 0.000, Figure 2) which indicates certain inconsistency in the distribution structure of the measured results.

Table 3 presents the results of the0020regression analyses with a calculated model of predicting the score distribution position for the applied running agility tests.

Table 3 Regression analyses and calculated prediction models

Predictors	Dependent Variable	Adj R^2	Std. Err. Est.	ANOVA of regression F value	p
505	Score_505	1.000	0.003	1134520.7	0.000
Agility Test	Model of prediction: Score_505 = 274.59942 – (505 Agility test (sec) • 71.78201)				
Envelope	Score_ENV	1.000	0.003	1047850.2	0.000
test	Model of prediction: Score_ENV = 355.61145 – (Envelope test (sec) • 39.68338)				
Illinois	Score_Illinois	1.000	0.003	1029826.6	0.000
test	Model of prediction: Score_Illinois = 349.24793 – (Illinois test (sec) • 16.78949)				

4. DISCUSSION

Based on the obtained results (Table 1) it can be concluded that average results in this study for the evaluated *505 Agility test*, *Envelope test* and *Illinois test* are at the level of 3.129 ± 0.232, 7.701 ± 0.420 and 17.824 ± 0.993 seconds, respectively, as well as that similar results were obtained for the *505 Agility test* (3.13 ± 0.138) (Yanci et al., 2017), then for the *Envelope test* (7.06 ± 0.26) (Erikoglu, & Arslan, 2016); 7.01 ± 0.65 (Kutlu et al., 2014); 25.21 ± 1.10 (Lipecki, 2018); 7.45 ± 0.20 (BrianMac Sports Coach, 2020); 4.5 - 7.00 (Nimphius et al., 2018); as well as for the *Illinois test* (16.26 ± 1.02) (Howard, & Stavrianeas, 2017; Born et al., 2016).

It can also be said that all the results are very homogeneous, because the variation coefficient (cV) is under 10.0% for all the tests, i.e. it ranges from 5.45 % for the *Envelope test* to 7.41 % for the *505 Agility test.* Adding the fact that the relative value of the standard measurement error for all three tests is under 0.5% (from 0.30 to 0.41% for the *Envelope test* and the *505 Agility test*, respectively, Table 1), it can be said that all the tests were carried out uniformly in terms of methodology and following a strict measurement procedure, so that the obtained results can be accepted as very representative.

The results of the distribution normality have shown that the distribution test result for the *505 Agility test* and the *Envelope test* is regular (K-S Z 0.057 and 0.039, $p \geq 0.200$) while the only test with an irregular result distribution is the *Illinois test*, i.e. the test with the narrowest duration range (Min-Max = 15.41 - 19.67 s, Table 1), as well as the most motor complexity - which was indeed why it was given to the oldest player age group, the 15-year-olds. The distribution is in the form of a bimodal curve (Figure 2), i.e. the participants are grouped around the above and below average values of the given test.

The displayed graphs of distribution normality obtained by applying the K-S test clearly indicate that in the 8 and 11 age group, empirical distribution does not deviate in a statistically significant way from normal distribution with a 5% margin of error. However, the graph for the third distribution clearly indicates a certain inconsistency of the structure of distribution normality. It might be assumed that the noted heterogeneity of the obtained results in the study for the age group of 15-year-olds may have multiple reasons. The first stems from the fact that at this age, the participants exhibit more significant differences in the efficiency of performance of both basic and, perhaps even more so, specific motor capacities (skills). It is possible that the difference is less prominent in younger age groups because these periods are characterized by a more significant (60-80%) application of general and focused exercises, which have a general and almost equal effect on all young athletes doing the exercises. Hence, as the length of the training history increases, so does the difference between less efficient athletes and those for whom the skill of carrying out motor tasks becomes the result of the effect of positive transfer, i.e. the quality of their adaptation to the effects of applying specific forms of exercise. This is, of course, the privilege of the better, the best, and most talented athletes. The second important reason might be the fact that the sample of participants for the study comprised participants who are in training with national teams, clubs, and football camps, i.e. of children with three different levels of knowledge and capacity. This particularly refers to participants from summer camps, who include some children who have a very low level of capacity and football skills, but have been included in this study. The third, very notable reason might be the fact that in such a large sample of participants, there can hypothetically be a proportionately large number of boys whose

chronological age does not match their biological age. This in turn produces results which do not fit the current chronological age of the given sample, which is an established criterion in this study. Namely, it is well documented that the maturity process does not follow the same pattern for every individual. So, young players of the same chronological age, but who are biologically more advanced, are taller and heavier than those players that develop later on, and can therefore potentially exhibit a greater quality of motor manifestations (Malina et al., 2004; Valente-dos-Santos et al., 2012). In this study, the year in which the height increment peaked for young players (attacking players) was 14.84 ± 0.30. Similar arguments that young football players exhibit increments in weight, height, running speed, and aerobic endurance near the height increment peak were stated by Philippaerts et al. (2006). In can be said that the findings in this study for players aged 15 are similar to that of previous claims. It is therefore possible that the heterogeneity of their results is the consequence of the relation between chronological and biological age, which is especially prominent at this age, and which affected the distribution normality (third graph). Failure to identify the issue of this relation systematically excludes talented players who mature at a slower rate, which is impermissible in diagnostics, prognostics, and the modelling standard for recognition of young talents in football.

Defined test standards are diagnostic decision-making criteria in the sense of evaluating the current level of a given motor ability of the tested individual (Table 2). This allows the coach to monitor both the absolute and the relative development trend of the given player over longer training cycles. In other words, this methodology makes it possible to not only monitor absolute changes in the sense of the development of the given motor capacity (changes in the individual's result in seconds – result progress, or result decline), but also to monitor the relative development trend, i.e. the change of the individual's position (progress or decline) in relation to the distribution scale, i.e. age group (result score). On the other hand, defined standard norms in terms of the numerical value of the score broken down for each individual test give the coach information on the hypothetical placement of the given individual in relation to other age groups, i.e. the absolute age population range for the measured ability (Table 2).

The calculated prediction models are mathematically defined at the level of the absolute explained common variance (Adj R^2 = 1.000, i.e. 100.0% of the explanation) with a marginal standard error of the prediction (only 0.003 points, Table 3). Unification and distribution standardization make it possible to define an individual's position in relation to the population age, i.e. to apply an individual approach of controlling the effects of the applied training programme, and thus to monitor the level of the individual's adaptation throughout a year-long training period in relation to the rest of the group, which is the foundation of the modern concept of controlling the effects of sports training (Majstorović et al., 2020; Nikolaidis et al., 2012; Muazu Musa et al., 2019).

The defined prediction models for the population positioning of the results of the applied agility tests for young football players in the tested age groups (Table 3) have the potential for standard application within programmes for the development of football talents in terms of recognizing motor talent (Malina et al., 2004).

Some limitations of this study must also be pointed out. Certainly, even though the current data should be applied within talent development programmes, other components as well, such as power characteristics, sports skills, tactical variables, psychological and social factors, which, unfortunately, have not been analysed in this study, may be of importance for success in football (Meylan et al., 2010; Scanlan et al., 2021). Further, in

order to create a full profile for each of the playing positions in identifying talents and the development of young football players, future research should focus on the separate analysis of each position in a large group of young football players.

5. CONCLUSION

Contemporary sports use assorted sophisticated diagnostics procedures for measuring an athletes' capacity, skills, traits, and knowledge for the purpose of various scientifically verified models of evaluating their physical condition and sporting condition. Results evaluated and explained in such a way are the foundation for quality planning, programming and control of training processes. Results of high quality and accuracy allow for setting clearly defined goals, tasks, and preparation cycles, and accordingly, implementing suitable means, loads and methods of training work.

This study highlights one of the possible new, scientific approaches to evaluating athletes' identified capacities, which are becoming increasingly topical in training practice. In other words, this means that each highly ranked sports results is inevitably preceded by the application of highly sophisticated diagnostics and prognostics, established on the basis of clear, precise, scientifically affirmed standards, high quality evaluation (quantification) of measurement results in relation to the modern concept of controlling the effects of sports training, as well as optimally defined concepts, projections, and strategies for the development of an athlete.

The defined mathematical models for the prediction of the level of development of the measured agility type do not only have absolute, but also hypothetical potential for determining the relative position of each young player in relation to their age population, and have strength at the level of the absolute explained common variance (Adj R^2 = 1.000, i.e. 100.0% of the explanation) with a marginal standard error of the prediction (only 0.003 points, Table 3). The application of these model provides coaches with an individual approach of controlling the effects of the applied training programme, and thus of monitoring the level of an individual's motor adaptation throughout a year-long training period with maximal efficiency in relation to the rest of the group, which is the foundation of the modern concept of controlling the effects of sports training.

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STANDARDIZOVANI PLANIRANI TESTOVI AGILNOSTI KOD MLADIH FUDBALERA: MATEMATIČKO MODELIRANJE U FUNKCIJI DEFINISANJA FIZIČKOG POTENCIJALA

Svaki proces efikasnog upravljanja stanjem sportiste podrazumeva odgovarajuću dijagnostiku, prognozu i modeliranje merenjem prikupljenih informacija. Ova studija ima za cilj da dođe do standardizovanog matematičkog modela za procenu fizičkog stanja mladih fudbalera u odnosu na planiranu i programiranu agilnost. Ovom studijom implementiran je metod matematičkog modeliranja za opšte profilisanje procenjenog motoričkog kapaciteta, kako bi se dobio alat za klasifikaciju stanja pojedinca u odnosu na standard populacije. Ova studija je primenila planirane i unapred programirane obrasce pokreta za testiranje kapaciteta planirane agilnosti, koristeći šest varijabli: 3 originalne i 3 izračunate. Sve originalne varijable su pretrpele matematičku transformaciju u odnosu na višeskalno modelovanje Z-distribucije, tako da su svi rezultati transformisani u analogni rezultat u opsegu između 0, kao minimuma distribucije, i 100, kao maksimuma distribucije. Ovo je proizvelo analogne kvantitativne, odnosno numeričke vrednosti skora, odnosno distributivnu poziciju svakog rezultata u odnosu na ispitanu starosnu grupu. Definisani matematički modeli za predviđanje stepena razvoja merenog tipa agilnosti poseduju ne samo apsolutni, već i hipotetički potencijal za određivanje relativnog položaja svakog mladog igrača u odnosu na njegovu starosnu populaciju. Predloženi modeli imaju snagu na nivou apsolutno objašnjene zajedničke varijanse (Adj R^2 = 1.000, tj. 100,0% objašnjenja) sa marginalnom standardnom greškom predviđanja (samo 0,003 poena). Obrada dijagnostikovanih informacija na ovaj način omogućava precizno definisanje početnog, tranzitnog i konačnog stanja sportiste, programiranje efikasnog, optimizovanog i kvalitetnog trenažnog procesa, kao i pravilnu identifikaciju talenata u selekciji mladih sportista.

Ključne reči: *dijagnostika, planirana agilnost, modelovanje, predvidjanje, standardizacija*

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Review article

ASSIGNMENT OF BROADCASTING RIGHTS AS A SOURCE OF FINANCING SPORTS ACTIVITIES

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Abstract. *The goal of this paper is to provide a review of the transfer of rights to broadcasting sporting events as one source of financing sporting activities and clubs through comparative practice and current legal regulations. Sports and the law are deeply intertwined, primarily due to the fact that sports are exposed to various challenges, ranging from doping, prevention of violence at sports manifestations, all the way to competition regulations, managing sports organizations and business processes. In this paper, we will analyze the positive legal regulations that enable the realization of income based on the right to broadcast. Sources of financing are necessary for the conduct of sporting activities. The most successful clubs generate the biggest part of their revenue through leasing broadcasting rights for sporting events and marketing. Broadcasting sporting events not only enables generation of direct revenue, but also removes the shackles of previously existing spatial barriers and thus contributes to the popularity of sports, athletes and their clubs. Occurrences such as the coronavirus pandemic have led to the organization of sporting events in controlled conditions, without the presence of an audience or with numerous limitations and restrictions. In such situations, numerous institutions have offered interactive forms of communication with the consumers (online museum tours, concerts, etc.), thus not only minimizing losses, but also maintaining contact with the audience. This situation has proven the significance of digital communication with the consumers. Even though the year 2020 went by without the previously planned Olympics and, in most cases, without sports fans in the stands, the sporting industry recorded a jump (from 388.28 billion dollars in 2020 to 440.77 billion of dollars in 2021). The growth in earnings was achieved predominantly due to the increase in media revenues.*

Key words: *sport, financing, broadcasting, sporting manifestations, mechanism of solidarity in sports.*

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INTRODUCTION

Whether sports emerged from the need of man for games is yet to be determined by science, but we can undoubtedly say that it stopped being a game a long time ago, and is more and more directed towards generating profit. Contemporary sports are not deprived of fun and a positive impact on the development of the human body, but they have largely become an economic branch that generates huge profits. For the owners of sports clubs, as well as for the athletes themselves, profit is often more important than trophies, which leads to a departure from the basic competitive principles on which sports were created. In order to survive, "small" sports require material support, which is also important for creating conditions for the development of the youth, as well as for the survival of sports in smaller communities.

Even though the presence of spectators at sporting events often has even a decisive influence on their conduct, in the last few decades, the popularity of media broadcasting is on the rise (Rotondo, 2015). The development of mass-media, as well as increasingly advanced technologies, enabled faster and more interactive broadcasting of sporting manifestations from all geographical meridians, reaching even the most distant regions and biggest poverty, thus widening the circle of users onto literally the entire planet (Milutinović, 2015). With overcoming physical distance between the venue of sporting events and the consumers' place of residence (Spasić, 2011) came the changes in cultural, social and other relations, which have, to a significant extent, contributed to commercialization of sports in general.

Most countries recognize sports as a category of significant social interest (Strategy on Sports Development in the Republic of Serbia for period 2009-2013/"The Official Gazette", no. 110/2008), since they help the promotion of social and educational values, health, as well as contribute to the international reputation of a state and connects people (Tomić, Tomić, Pavić, Madžar & Primorac, 2019), encourage confidence and tolerance, strengthen team spirit and the respect for discipline, impact the ability to adjust and accept competition, etc. (The Strategy for the Development of Sports in the Republic of Serbia for the Period from 2014 to 2018, "The Official Gazette", no. 1/2015). By performing a public activity of special social interest through the creation and broadcasting of radio and television programs, the broadcasters in fact use the intellectual creation and performance of third parties.

Authorization to broadcast sports event

With the growth and rapid evolution of sports, and especially with the expansion and popularization of football, the television broadcasting of the most significant sporting manifestation gained significance as well, given that they actively impact the affirmation of sports and their popularization among the youth through their indisputable influence on the television audience (Ilić, 2021). Intellectual property rights contributed to sports becoming an industry measured in hundreds of billions of dollars, thus making the revenue made through selling tickets just a smaller segment of profit generation.

Intellectual property is a field of civil law consisting of industrial property rights (patents, trademarks, geographical indications and topography of semiconductor products) and copyright and related rights. The Law on Copyright and Related Rights regulates these issues. Copyright regulates the rights of literary, scientific and artistic works (Stojanović, 2008). Related rights include: performing rights - the right of the performer, the right of the film producer - the producer of the videogram, the right of the phonogram - the right of the producer of the phonogram, the right of the producer of the show, the right of the producer of the database and the right of the first publisher. The Law on Copyright and Related Rights

("Official Gazette of the RS", No. 104/2009, 99/2011, 119/2012, 29/2016 - US decision and 66/2019) is considered to be public broadcasting by broadcasting radio or television program signals, from the broadcasting entity, to receiving devices via a network of transmitters (terrestrial broadcasting), cable distribution systems (cable broadcasting) or satellite stations (satellite broadcasting). Our positive law does not view sports events as copyrighted works but as a subject of related law (Popović, 2012). The subject of protection of this right is the broadcast of certain content, regardless of whether it is a copyright work or not. The subject of protection is neither the broadcast signal, nor the content that is the subject of the show, but the producer of the show enjoys related legal protection "on the totality of the broadcast content" (Ljubojev & Dukić-Mijatović, 2018).

The issue of providing legal protection for organizers of sporting events and their monopoly over broadcasting rights is not equally resolved in comparative law. Italy, like Serbia, ensured protection of sporting audiovisual rights through producer rights – broadcasting rights. In France, the protection is being ensured in spite of the authorship and related rights, and it is being ensured in accordance with Article L333-1 of the French Law on Sports (Code du sport Article L333-1), which gives the organizers of sporting events the right to manage sporting events and competitions (The Draft Report with Recommendations to the Commission on the Challenges of Organizing Sports Events in the Digital Environment, 2020).

The Court of Justice of the European Union stated its opinion in the case of Football Association Premier League Ltd, as well as in the case of Caren Murphy, that sports events are not considered an author's work because they are not a "work", because they are "subject to rules of the game, which does not allow creative freedom in terms of copyright ", but given that each sporting event is unique and in this respect original, the protection of their property rights is governed by related law (the producer of the show) (Draft report with recommendations to the Commission on challenges organizers of sporting events in the digital environment, 2020). The subject of protection of broadcasting sports events is not intellectual creativity, but the industrial activity of the producer of the show, who invested certain resources in its creation and broadcasting (Ljubojev & Dukić-Mijatović, 2018).

The development of broadcasting radio and television as forms of electronic media of mass communication which transmit movable and non-movable pictures in the forms of program content directed towards the broadest public via radio-waves or the cable distribution system to the suitable receptors brought about the need for providing protection to broadcasting agencies from unauthorized use of shows, their unauthorized recording and duplication, as well as from unauthorized public presentation. The basis for the introduction of this type of legal protection is not founded in the mere need for legal protection of this type of activity, but first of all in the general interest of spreading information and culture provided by this type of activity (Henneberg, 2001). This right is enjoyed by producers of audiovisual works for the first recording, as well as broadcasters (The Draft Report with Recommendations to the Commission on the Challenges of Organizing Sports Events in the Digital Environment, 2020). The organizers of sporting events are the carriers of the rights, and thus they can act as producers, or transfer these rights to a third body by contract.

The emergence of new technologies conditioned the fact that, besides television operators, many telecommunication companies and online video platforms are increasingly and more strongly participating in the market of sports broadcasting. Nowadays, there are several hundred television stations broadcasting sporting content world-wide. In such a harsh

competition, many multimedia companies have recognized sporting events broadcasting as a comparative advantage, putting exploitation of these rights first (Evens, Iosifidis & Smith, 2013), due to which the growing sums of money are needed to cede the rights to broadcast sports TV programs. The broadcasters that are not able to financially partake in this race are often oriented towards "small" sports, thus quenching the "hunger" of consumers for sporting contents.

Thus, for an increasing number of sports clubs and associations, the assignment of broadcasting rights has become the dominant source of income, which enables transfers of successful athletes, and daily maintenance and investment in infrastructure. By granting exclusive broadcasting rights to the media, broadcasters today sell much more than the broadcast itself. Besides the revenue that can be acquired through subscriptions for watching sporting events, significant profit is also made through advertising and sponsoring sporting manifestations. The rights of the show producers last 20 years from the moment of broadcasting of the first protected show.

Broadcasting "live" program through radio diffusion does not exhaust all the possibilities for using this work. This primarily implies the recording and reproduction of videos, that is, allowing the event to be recorded (Urem, 1969). Given that the recordings of sporting events usually satisfy the necessary level of originality, they do enjoy protection as authorship works, according to what their reproduction, copying, multiplication, and distribution in any way for commercial purposes is forbidden. Everyone who wishes to publish a broadcasted content or its part, no matter the media (electronic, print or Internet media), must get the written approval of the broadcaster.

A contract signed by the broadcaster and the authorized body (sports club, sporting association or an association they belong to or have previously authorized) means the assignment of rights the broadcasting rights for a certain sporting event, its parts or its recording. The contract also stipulates the time-frame within which the broadcaster is authorized to broadcast, as well as the territory on which the broadcast is conducted. Territorial restriction of broadcasting can be implemented in several ways: within the borders of a certain state, its federal unit or a region. It is quite common that every contract refers to one broadcaster solely, but there are also cases when the rights are being leased to several countries, especially in cases when several broadcasters exist within one network (Janjić, 1971).

Legal framework of regulating sports as an economic activity within the EU

Regulation of sports within the European Union has come a long way, growing from a benevolent attitude that implied encouragement of sports as an activity that is significant for healthy and regular development of the citizens of the union, sports for everyone (The European Model of Sport, 1999), to regulation of sports as an economic activity that must be harmonized with the rules of community laws that regulate the economic game. Equality and freedom on the EU market for all the participants is the basic mechanism of exercising market freedoms determined by Articles 101-109 of the Treaty of Lisbon, which forbid violation of competition, but also the use of state aid for this purpose (Medić, 2018).

The perception of sports, that is, more precisely said, professional sports as an economic activity that would be subjected to the EU rules on free market game, was definitely instigated by the decisions of the Court of Justice of the European Union in the case of Walrave, in which the opinion that sports, when representing an economic activity, must fall under the field of the UFEU, and the sports practice must fulfill the demands of the

European Law (Walrave and Koch v. Association Union Cycliste Internationale and Others, 1974). A significantly grand change in the perception of sports as an economic activity was caused by the Bossman case (Union Royale Belge des Sociétés de Football Association ASBL v Jean- Marc Bosman, 1995) whose Decision confirms that sport is subject to all relevant provisions of the TFEU whenever it comes to economic activities in sport, including the Community provisions on freedom of movement for workers, the application of which is not decisive for the employer to be an entrepreneur (par. 3 & 4) The decision helped clarify the limitations of the decisions and rules used by sports organizations. The ECJ found that the TFEU was subject to rules that not only had a specific purpose related to sport, but also required that the amount of the transfer be paid in the case of hiring a player for another club after the expiry of the contract. 5). This decision of the court shook all European umbrella sports organizations because after it, sport became an important issue in the agenda of European institutions, especially economic activities in football, which were in conflict with European law (Garcia, 2007).

Despite high level of criticism and resistance to the new position of professional sports, sports regulation went towards including sports in the legal activities of the EU (Niemann & Brand, 2008). A new approach to the issue of sports was opened by the adoption of the White Paper on Sport (2007). It also contained some controversial issues, such as those on player transfers and TV rights (Bačić & Bačić, 2011). Until the adoption of this act, the EU Commission did not have a significant role in sports issues, but this document emphasizes that "sports activity is subject to EU law" and that sport is subject to competition law, internal market provisions as long as it is an economic activity (Figlel, 2007). Equality and freedom in the EU market for all participants is the basic mechanism for exercising the fundamental market freedoms set out in Articles 101-109 of the Treaty on the Functioning of the European Union (hereinafter: UFEU), which prohibits distortions of competition and the use of state aid for this purpose (Medic, 2018). Sport should be subject to these rules in its economic activities.

At the same time, one should keep in mind the autonomy of sport (the founding EU did not provide for any special competence of the Union in the field of sport until the Lisbon Treaty), which is indisputable for all sports that do not produce economic effects of sports rules. In this sense, every act of a certain sports federation can be subjected to the EU Law compliance test, and thus, if determined that it violates some of the basic market freedoms, it can be subjected to possible restrictions (Medić, 2018). Up until the Treaty of Lisbon, sport regulations were based on EU court decisions, recommendations of the European Commission, and the soft law instruments. The most significant documents from this corpus are the Amsterdam Declaration, together with the Amsterdam Contract, as well as the Nice Declaration (2000) and the Nice Contract. Therefore, the focus remained on amateur sports and their social, educational, and cultural function, which was clearly pointed out in the White Paper on Sport (European Commission, 2007).

A new era of sports regulation within the EU has begun, as we have already emphasized with the adoption of the Contract on the functioning of the European Union – the Treaty of Lisbon. It defines (article 165) the jurisdiction of EU bodies in the field of sports, and it was determined that the Union will contribute to the encouragement of the European dimension in sports, taking into account the specific nature of sports, their structures based on volunteering, as well as their social and educational role. The economic activity in sports, as well as an increasing commercialization, have opened up a special sensitive issue of financing in sports within the field of regulation. For the European model of sports, defined by two basic

principles – solidarity and democracy (Scheerder, 2020), when speaking of the issue of financing, a partnership is necessary between the public authorities, sports organizations and the economy. It is characteristic that sports should be financed from public funds, and within these funds, the majority ends up being provided by the local community. Financing from public funds within the EU is based on decentralization. Thus, the foundation is the relation between providing funds from the state budget and providing them from the local community budgets, in favor of the local communities whose investments in sports have tripled in their communities (Đurđević, 2007). Generally speaking, the funds necessary for financing amateur and high-end sports are provided by the state. On one hand, investment in sports is directed towards ensuring good health of the nation, while on the other, towards promoting the state, its politics and values in the most efficient manner (Mićović, 2019). In France, for example, the state allocated 36.9 billion euros in 2017 (Institut national de la jeunesse et de l'éducation populaire, 2017).

Contrary to amateur and high-end sports that survive due to public source funding, professional sports are based on private source financing. In this case, sports represent an economic activity and it relies on their own sources, which constitute revenue acquired through selling tickets, memberships, donations, sponsorships, sales of goods marked with trademark for commercial purposes. Nowadays, in the world of new communication, the most significant source of financing for professional sports is the transfer of rights to broadcasting and re-broadcasting sporting events.

Rights to sports events broadcasting in the EU

Regulation of sports events broadcasting rights went through a gradual development, which grew hand-in-hand with the development of possibilities of broadcasting that were offered by the new technology, such as satellite broadcasting, which was to a great extent useful for the sports sector in Europe. Football was especially able to sell the sporting events broadcasting rights to the new wave of commercial operators who accepted the new technology (Parrish, 2003). The new trend confirmed that sports are slowly turning into the sports industry, that is, they have some features of economic activities, which require supranational regulation, and thus the European Union emerged as the key regulator.

The key problem that sports face in comparison to media and regulation of sporting events broadcasting on the TC within the European Union is the fact that sports club associations, such as the leagues and alliances, as well as international associations of national sports alliances, have the character of economic subjects with a monopoly, that is, a dominant position on the market. This problem is reflected in two directions – firstly in the internal relations of these subjects with their members, as well as in the international relations of the members. The other side of the problem is the relation of these subjects with third parties. In essence, the problem lies in the fact that alliances and leagues, according to the rule, are not the "original" carriers of broadcasting rights, since they are considered as the organizers of sporting events. The clubs, as organizers of sporting events, hold the original broadcasting rights in their hands. Legally speaking, the leagues, that is, the alliances, can get broadcasting rights only through a contract. This creates a controversial situation, because this is a classic monopoly practice which results in a restriction of the economic autonomy of clubs and a restriction of competition in the field of TV rights. The question is whether there is a basis to exclude this practice from the principle of prohibition of monopolistic associations and to consider it permissible, for justified reasons based on the specifics of sport in relation to other

economic activities. Even though the said problem should be resolved in accordance with the rules of competition and through mechanisms that refer to economic subjects, here it is not the case. In practice, special contracts are rarely signed on the topic of transferring broadcasting rights from the clubs to the league or the alliance, but it is believed that this issue is resolved through sports regulations of the alliance (league) that have the character of a contract for the clubs within this association (Đurđević, 2017).

The European Commission admitted that there is a difference between the method of work and assessment of the existence of competition in sports and other economic sectors. Justification, especially the concentration of TV rights in sports associations, was based on the specifics of the system of sports competitions that require coordination at a higher level of organization, such as associations. On the other hand, the concentration of TV rights in the hands of sports associations gives greater opportunities for their commercialization in a centralized way, in a package, for the entire cycle of competition. In principle, in sports, the goal of the game is not to eliminate weaker competitors, but to preserve the uncertainty regarding the results and nurture the rules in sports, so the Commission did not deal with the mentioned "sports rules". The rules, without which sports could not exist – in fact necessary for the organization of some sport or its competitions – should not, in principle, be subjected to application of EU competition rules (Schaub, 2002). Transfer of broadcasting rights to an alliance or a league, joint sale of broadcasting rights, could represent a horizontal limitation of competition, contrary to Article 101(1) of the UFEU, but they are included by exception through the acceptance of Article 101(3) of the UFEU in certain cases. Therefore, the European Court concluded in the Meca-Medina case (David Meca-Medina and Igor Majcen v Commission of the European Communities, 2006) that the specifics of the sports must be respected, but that the said case is not “a key that opens every lock”, and thus that sports problems must be resolved on a case-by-case basis. So, the Commission must thus examine every case separately in relation of the competition rules. In the White Paper on Sport (2007), the Commission recognized the essential role of audio-visual rights as the primary source of revenue for professional sports in the European Union.

In accordance with the previously stated attitude, the regulatory framework which governs the contracts on transfer of broadcasting rights within the EU recognizes several models for the transfer of broadcasting rights in sports. The first one is – common (collective) sale of rights, whereas the rights are being sold to already existing associations in the name of sports clubs. The collective sale enables the leagues and national sports federations to sell media rights to their games and sports collectively, and then reallocate the revenue among the clubs, national governing bodies and basic/mass sports (Parlasca, 2006). If some clubs or sports independently negotiate their rights, it might mean that there would be a lesser amount of revenue for them, and thus a smaller possibility for reallocation for mass sports or smaller sports.

The second model is exclusiveness – implying that the holders of broadcasting rights in sports should sell their rights exclusively to one broadcaster, which significantly increases their value. The issue that was to be solved here is the issue of the monopoly position and the competition rules of this form of sales. The European Commission passed in 2003 a Decision in which it spoke of competition, referring to the UEFA sale of media rights, which was, since then, used as a template for sports sale of media rights (European Commission decision, 2003). Sometime later in 2006, a Decision was passed on the Premier League (European Commission, 2006), and in 2003, the Decision on the Bundesliga (European Commission, 2003). The Commission explicitly supported the notion of exclusiveness, stating that the

"UEFA arrangement regarding the joint sale offers the consumers certain advantages of media products focused on the league of this pan-European competition of football clubs that are being sold through one point of sale which, usually, under different rules, could not be produced and distributed equally efficiently" (Article 53. of the EEA Agreement).

At the same time, this model enables the increase in advertising revenue, since the advertisers would have a defined target group. It was believed that the revenues generated with broadcasting rights through exclusiveness are increasing and bring along better conditions for the sport. All these benefits are stated in more detail in the Commission decision from 2003, and they support exclusiveness in the sense of economic efficiency. But what is more important for sports is the issue of allocation of funds acquired in such a way for the basic/mass sports. Due to that, the mechanisms of solidarity between the professional and basic sports are another significant factor for the world of sports (Expert Group on Sustainable Financing of Sport, 2017), and will later be further elaborated on.

The third aspect of broadcasting rights is the territoriality, because sports are linked to a certain territory. According to the rule, the competition provisions forbid measures such as absolute territorial protection, which limit the competition and creates divisions within the EU internal market. However, until now, the legal practice and the practice of decision-making regarding the territorial exclusivity in agreements within the carriers of audio-visual sports rights and providers of media content was interpreted in the sense that such absolute territorial protection in sports is allowed (Katsarova, 2017).

The Commission accepted this model for broadcasting rights (territorialism) in its decision on UEFA from 2003, in which it is stated that the media rights to football events, such as the UEFA Champions' League are usually being sold on the national basis. This is due to the character of distribution, which is national, as well as due to national regulatory regimes, language barriers and cultural factors. This is especially expressed through competitions of the national team or national clubs in international competitions, which represent a common interest within the broadcasting territory. Article 14 of the AVMSD (Directive 2010/13/EU) stipulates that the events of greater importance for certain members should be chosen and inscribed in advance on the list of certain sporting events that are being broadcasted for free. The European Commission must be informed on all the lists that are being adopted, as well as on the consent given by the Contact Committee (founded for the purpose of monitoring the said Directive). Here we can certainly mention several sporting events – from Giro d'Italia in Italy to the All-Ireland Senior Championship in Hurling in Ireland – which are predominantly of territorial significance, but their value and attractiveness differ throughout Europe (Expert Group on Sustainable Financing of Sport, 2012).

Solidarity mechanism in sports and the benefits of sporting events broadcasting rights within the EU

Extremely high revenue that is being generated from sporting events broadcasting rights, as a result of the commercialization of sporting activities, cannot remain within a certain club or a league that is the most popular or within a sport that has the biggest participation in this revenue, but, to some extent, it must be invested in basic sports. The European Commission adopted the "organized mechanism of solidarity in sports", one of the special characteristics of the sports structure, which enables recognition of the specificity of sports and the so-called European approach to sports. This has a special significance, given that Article 165 of the

Treaty of Lisbon enables the development of EU sports politics, with a special emphasis on specificity of sports and promotion of fair play in sports competitions (Laskowski, 2019).

The mechanism of solidarity in European sports is a term that implies reallocation of funds from one part of sports to another, that is, from professional sports into basic sports, or from one field of sports to another. This reallocation can be either horizontal or vertical. When speaking of horizontal reallocation, the distribution of funds is being conducted between different sports, and when we speak of vertical solidarity, then the reallocation is being conducted between different levels of the same sport. We have already pointed out that the UEFA gained special benefits in terms of joint sale of broadcasting rights, and therefore its role in solidarity in sports on the EU level is significant. According to the UEFA Financial Report from 2019/2020, the revenue generated from media rights for the said period amounted to 2,593.3 million euros, which is a total of 84.9% of total revenue of this association. According to the same report, 70% of the said revenue is being invested in different sports programs. From the available amount, about 80% is being reallocated to clubs of the national alliance that have at least one club participating in the group phase of the UEFA Championship League. The remaining 20% is being distributed to national alliances that do not have clubs participating in the group phase of the UEFA Championship League.

In other words, organized sport implies the existence of certain mechanisms for funds overspilling, and the most significant revenues come from media rights and player transfers. The associations which enjoy concentrated rights to commercialization of sporting events broadcasting have a commitment to reallocate most of their funds to other clubs, so that every club benefits from broadcasting, no matter whether it participated in the concrete competition. Finally, the uniqueness of organized sports refers to the fact that there is no high-end, that is, professional sports is the system of recruitment, and training of younger athletes is not provided (Đurđević, 2017).

The sporting events broadcasting rights in the Serbian environment – regulations and dilemmas

The regulation of rights to sporting events broadcasting in Serbia is based on the fundamental principles accepted and derived from the legal framework of the European Union which treats sports as a category of significant social interest. The relation of sports and the media is regulated by several legal sources. The strategy of development of sports within the Republic of Serbia recognizes revenues generated through sale of TV rights as a source of financing in sports, but it was, at the same time, said that they are quite small (Strategy of Sports Development in the Republic of Serbia 2014-2018), and the relation of media and sports, according to the same document, asks for mutual cooperation through national associations and media representatives (Strategy of Sports Development in the Republic of Serbia 2014-2018). Furthermore, legal sources of regulation of broadcasting rights are found in the Law on Sports, which regulated the jurisdiction of sports associations in this field (The Official Gazette RS, 10/2016). A very significant legal source is the Law on Electronic Media (Official Gazette RS83/2014 & 6/2016) which regulates broadcasting rights, among other things, of sporting events as well, in accordance with the previously mentioned rules within the European Union, where the model of exclusiveness and territoriality is governed on a national level. The Law on Electronic Media (article 64) stipulates that the "provider of the service of television broadcasting under the jurisdiction of the Republic of Serbia cannot exclusively broadcast the events that are on the list of the most important events of special

significance for all the citizens in a manner that would deprive a significant part of the public in the Republic of Serbia, EU member state of a state that has signed an international agreement that is legally binding for the Republic of Serbia of following these events".

The mentioned article of the Law on Electronic Media stipulates that, as in the European Union, the obligation of making the list of the most significant sporting events, not only local, but foreign as well, that are of special significance for all the citizens and to which the exclusive right over broadcasting can be enjoyed solely by the provider of the television broadcasting service to whom the access is free and whose coverage zone includes the entire territory of Serbia, and of which the said provider informs the European Commission (The Official Gazette RS 83/2014 & 6/2016). In order to entirely regulate the issue of determining the said lists, a Rulebook on the manner of formulation of the list of the most important events of special significance for all the citizens and enjoying the rights to access to events of big interest for the public was passed (The Official Gazette RS, no. 25/2015) and has been implemented since 2015. This bylaw more closely regulates the method and conditions for forming the list of sporting events of big interest for the public.

Formally speaking, there are conditions and regulatory frameworks that enable the source of financing in sports from sale of broadcasting rights to be developed in our country as well. Unfortunately, numerous examples from the practice deny that. The European club association published this year as well detailed research regarding the revenue generated through TV rights which the participants in European competitions enjoy in national championships, and what is interesting for Serbian football is the fact that the "Red Star" club is undoubtedly ranked last on the list.

The "Red Star", in spite of great sport results achieved in the previous several years, has been placed last when speaking of revenue generate from the sale of TV rights to the national championship. On an annual basis, this club earns 80 thousand euros from the sale of TV rights for the national championship, which is incomparably less than all the other European teams. The revenue generated from TV rights makes up to 0,3% of total revenue of this club, while the revenue of other clubs in the region generated through TV rights amounts to 30 to 40% of the total revenue. It is difficult to explain how clubs in the region, that is, in the Western Balkans countries (Bulgaria or Croatia) generate much higher revenues from this right, while in our country the results are lacking, that is, the revenues are almost negligible (for example, "Dinamo" from Zagreb generates 500 thousand euros from TV rights, and the "Rijeka" football club generates about 250 thousand euros) (Ivanović, 2021). Obviously, the problem lies in the insufficient understanding of commercialization of sports and the demands of the contemporary moment to direct sports towards private sources of funding, which is present in our public.

CONCLUSION

In countries in which there is no financing system in high-end sports and where prices of sporting manifestations tickets cannot be as expensive as in Western countries, as is the case in Serbia, financing sports is, to the greatest extent, left to the local government bodies that are not able to sufficiently provide adequate conditions for practicing these sports. Due to the significance sports hold as a part of the mass culture and the reflection of the state of the society, the nurture of sports also represents the nurture of the values it represents: nobility, determination, sportsmanship, bravery, etc. Still, Western perception of sports, which has

become dominant, is to a great extent directed atz self-financing, and thus, all forms of financing of sports are important for their survival and further development.

The examples of the most elite basketball competitions, the Euro League and the Olympics, testify to the symbiotic relation between sports and the media market. Contrary to the former Championship Cup, where only the achieved sports results were cherished, upon selection of new members of the Euro League, priority is given to clubs from the countries that are recognized as big markets. Even the International Olympic Committee tailors the list of Olympic sports "in an attempt to attract younger audience and express the trend of urbanization of sports" through actually adapting to the sensibility of the sponsors that follow the broadcasting of this sporting event.

In the Republic of Serbia, smaller national broadcasters of sporting events have on numerous occasions pointed to the fact that the broadcasts of the most attractive foreign sporting championships have a negative impact on the interest for local sports. Moreover, small markets, such as ours, cannot successfully generate revenue from broadcasting rights that could provide a quality organization of infrastructure expenses or finance the arrival of high-end sports stars. However, if sports associations and clubs were to systematically organize financing, then the revenue generated through transfer of rights could surely represent a significant support in ensuring an adequate ambiance for the conduct of sporting activities.

A special problem is the realization of the mechanism of solidarity in sports in the right measure, horizontal solidarity and vertical. A state can, from its own revenue, provide for just one part of the funds necessary for the development of sports, which is not enough. Thus, the revenues generated through sporting events broadcasting rights should contribute, as the new source of finance, to the stronger development of sports and provision of continuity in creation of sports youth.

The generation of revenue through donations or sponsorship is legitimate and would not cause any dilemma, if only they were not made by companies whose shares are owned by the state. The question is whether in such cases it is a violation of competition in the market or a violation of the principle of solidarity in sports, whether such revenues can be considered revenues from public sources or are they revenues from private funds. This opens a wide range of questions, especially if we take into consideration the fact that the real situation in financing of sports quite differs from the one provided by our regulations.

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USTUPANJE PRAVA NA EMITOVANJE KAO IZVOR FINANSIRANJA SPORTSKIH AKTIVNOSTI

Cilj ovog rada je da se kroz uporednu praksu i aktuelnu zakonsku regulativu da osvrt na prenos prava na emitovanje sportskih događaja kao jedan od izvor finansirana sportskih aktivnosti i klubova. Sport i pravo su duboko povezani, prvenstveno zbog toga što je sport izložen različitim izazovima od dopinga, preko sprečavanja nasilja na sportskim manifestacijama, do takmičarske regulative, upravljanja sportskim organizacijama i poslovnim procesima. U radu ćemo analizirati aspekte prava koji omogućavaju ostvarivanje prihoda po osnovu prava na emitovanje. Za odvijanje sportskih aktivnosti neophodni su izvori finansiranja. Najuspešniji sportski klubovi najveći deo svojih prihoda ostvaruju kroz ustupanja prava na prenos sportskih događaja i marketing. Prenos sportskih događaja ne omogućava samo direktne prihode od emitovanja već i skida okove ranije postojećih prostornih barijera i tako doprinosi popularnosti sporta, sportista i njihovih klubova. Pojave poput pandemije virusa KOVID-19 uslovile su održavanje sportskih događaju u kontrolisanim uslovima bez prisustva publike ili uz brojna ograničenja i restrikcije. U takvim situacijama mnoge institucije ponudile su interaktivne vidove komunikacije sa konzumentima (onlajn obilasci muzeja, koncerti i sl.) umanjujući gubitke ali i održavaju kontakt sa publikom. Ta situacija pokazala je značaj digitalne komunikacije sa konzumentima. Iako je 2020. godina protekla bez planirane Olimpijade i uglavnom bez navijača na tribinama sportska industrija je zabeležila skok (sa 388,28 milijardi dolara u 2021. godini na očekivanih 440,77 milijardi dolara u 2021. godini). Rast je ostvaren prvenstveno zahvaljujući povećanjem medijskih prihoda.

Ključne reči: *sport, finansiranje, sportske manifestacije, Mehanizam solidarnosti u sportu*.

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Research article

DOMINANCE-INDUCED MODIFICATIONS ON MAXIMAL FORCE AND NEURAL ACTIVATION OF THE ANKLE MUSCLES

UDC 796.012.112:612.745
796.015.132:612.741

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Abstract. *The purpose of the present empirical study was to assess the differences in dominance between lower limb maximal voluntary contraction (MVC) and neural activation. Twenty active and right-leg dominant (age: 31.3 ± 9.5 years, height: 178.2 ± 7.6 cm, weight: 76.5 ± 11.0 kg) participants performed 3 maximal dorsal flexions (DF) and plantar flexions (PF) at 3 ankle angles (75°, 90°: anatomical position, and 105°) which corresponded to short, intermediate and long lengths for DF muscles and the opposite for PF muscles. Electromyography (EMG) was used to assess ankle muscle activity (tibialis anterior, gastrocnemius medialis and soleus). The results showed non-significant differences between lower limb MVC force and EMG-muscle activation. However, a significant main effect of the angle was observed. During DF, the MVC force was greater ($p < 0.05$) at 90° and 105° than at 75° for both legs and during PF, the MVC force was greater ($p < 0.05$) at 75° and 105° than at 90° for both legs. Moreover, during DF and PF, the EMG-muscle activation was greater ($p < 0.05$) at 105° than at 75° an 90° for both legs. The results indicate that dominance was not associated with different levels of force and neural activation during maximal voluntary contraction with the ankle muscles. It is concluded that dominance does not have an impact on maximal strength and neural activation of the ankle muscles and any mechanisms that contribute to the dominance effect were not evident within this experimental protocol.*

Key words: *Leg dominance, maximal voluntary isometric contraction, electromyographic muscle activation, dominant leg, non-dominant leg, force, lower limb*

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1. INTRODUCTION

Leg dominance is an often-discussed factor amongst both healthy and injured athletes. The term of dominancy is defined as the preferred use of one side of the body, which shows superiority in movement performances than the other side of the body (Hebbal, & Mysorekar, 2003). Empirical evidence supports the claim that maximal force in a right-handed person's upper limbs appears significantly higher for the dominant (right) than for the non-dominant hand (Li et al., 2015; Mitchell et al., 2017). Indeed, previous studies concluded that these differences were due to the cerebral cortex of the so-called dominant (left) hemisphere which controls most voluntary movements on the opposite side of the body (Adamo, Scotland, & Martin, 2012; Martin, & Adamo, 2011).

Previous studies have shown that more than 90% of the population is right-handed (Debbarma, & Mehta, 2018). Considering the dominance of the lower extremities, the dominance of the right leg is manifested in 60% to 82% of the population (Taylor et al., 2007; Zouhal et al., 2018). Several studies revealed differences in many biomechanical parameters of the lower limbs such as the vertical jump, moving time, reaction time, and torque around a joint (Ball, 2011; Kobayashi et al., 2013; Rumpf et al., 2014; Sinsurin et al., 2017; Zouhal et al., 2018). These asymmetries between limbs in healthy individuals could lead to injuries (Knapik et al., 1991). Although, it is reported that a leg's dominance asymmetries could often disappear, in case the subjects could perform at much higher frequencies or higher level of force ability (Carpes et al., 2010). Therefore, taking into consideration the abovementioned, the scientific question that arises is whether a leg's dominancy can affect the maximal lower limb force. In the classic study of Knapik et al. (1991) it is reported that asymmetry up to 15% seems to be the upper limit for healthy limb function. More recently, the asymmetry between legs in dorsiflexion and plantar flexion maximal forces was confirmed (Valderrabano et al., 2007). Finally, other studies demonstrated an asymmetry in plantar flexors maximal force up to 45%, rather than the recommended 15% (Furlong, & Harrison, 2015). This means that such observed individual differences (Smak et al., 1999) could be highly dependent on the used test (Jones, & Bampouras, 2010), and due to a variety of factors, such as neural control (Adam et al., 1998; Fort-Vanmeerhaeghe et al., 2015), sport one side preference (Ball, 2011; Nunome, Ikegami, Kozakai, Apriantono, & Sano, 2006), and injury (Croisier, 2004).

Understanding the mechanisms that influence the function of ankle plantar flexors (e. g. soleus, gastrocnemius medialis, tibialis anterior) is important for exercise and therapy since it has been shown that these muscles are very often injured in the field of sports (Fong et al., 2007). Further, the tibialis anterior muscle is researched in patients after CNS traumas (Merletti et al., 1978) and a history of falls (Perry et al., 2007; Skelton et al., 2002). However, an ideal method to determine leg dominance in relation to task performance is still lacking. Therefore, the aim of the present study was to investigate the effect of dominance on the lower limb's maximal and subsequent neural activation during dorsiflexion and plantar flexion. A secondary purpose was to examine the influence of joint angle on strength and activation of these muscles.

2. Material and Methods

2.1. Participants

Twenty active and right-leg dominant males (age: 31.3 ± 9.5 years, height: 178.2 ± 7.6 cm, weight: 76.5 ± 11.0 kg), participated in the study. They reported no cardiovascular and neurological disorders or injury to the legs and were asked to refrain from taking alcohol, medication, or participating in strenuous activity 24 h prior to testing. Approval (ERC-013/2020) was obtained from the Aristotle University Ethics Committee on Human Research in accordance with the Declaration of Helsinki.

2.2. Experimental procedure

In order to assess lower limb dominancy, all participants voluntarily completed the self-reported Waterloo Footedness Questionnaire-Revised for leg dominance (WFQ-R; Van Melick, Meddeler, Hoogeboom, Nijhuis-van der Sanden, & van Cingel, 2017), and provided written informed consent, approved by the Institutional University Review Board and in accordance with the Declaration of Helsinki. All volunteers were asked to be available for three laboratory sessions. At the first session, participants were familiarized with the testing procedures, protocols, and performance of MVC. The second session was used to obtain baseline measurements, which included anthropometric characteristics, signed informed consent, and leg dominancy determining. Force and EMG recordings were assessed during the second and third session; the two limbs were tested randomly.

2.3. Experimental setup

The experimental setting consisted of an adapted ankle ergometer (OT Bioelettronica, Torino, Italy), attached by a dynamometer and two adjustable belts. All participants sat comfortably upon an adjustable electrical table, with their dominant/non-dominant leg placed in the ledge of the dynamometer, whereas the foot was tightened with straps (~ 2 cm wide). The hip position was adjusted at an angle of 110° and the knee joint angle adjusted at 120° (180°: full extension). To examine the muscle-tendon length effect, 3 ankle angles were selected, 75°, 90° (anatomical position) and 105°, corresponding to short, intermediate and long length for the dorsiflexors (tibialis anterior), and inversely for the plantar flexors (gastrocnemii and soleus). Two digital bipolar goniometers with a single degree of freedom (MLTS700, AD Instruments) were used to continuously measure the knee and ankle angles. The foot was fixed with straps to the adjustable base that was continuously connected with the calibrated cell (CCT Transducer, Model TF 022., Toronto, Italy). The fixing feet straps were placed over the distal third of the metatarsal bones and immediately in the front part of the ankle. After familiarization with the setup and a standardized warm-up (5 submaximal isometric contractions of 20-40% MVC), the participants performed 4 maximal isometric contractions of 5s with the dorsiflexors and the plantar flexors in the 3 ankle angle positions. Time (up to 2 min) was provided for rest between trials. The applied force was measured and displayed on a 50-inch monitor located at eye level ~ 1.5 m in front of the participant (Figure 1).

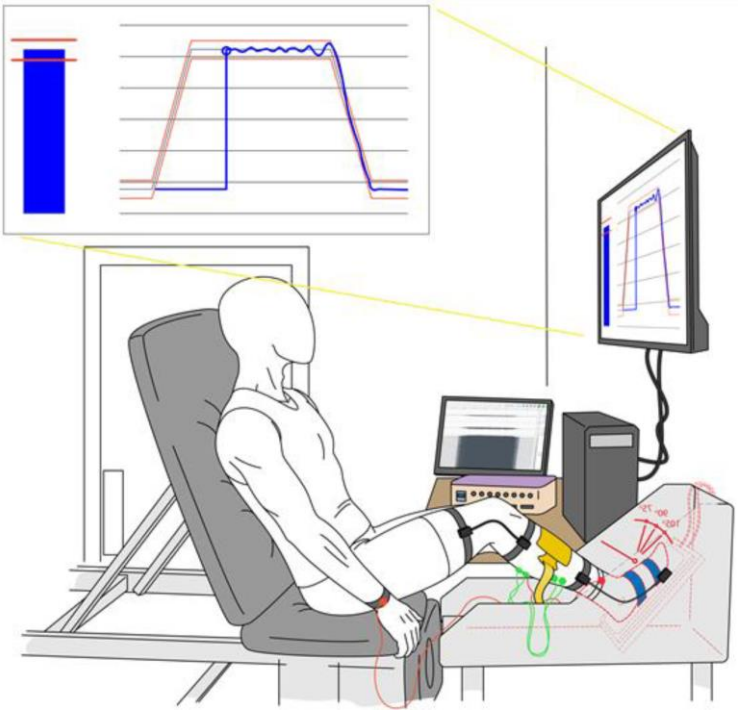

Fig. 1 The experimental setup consisted of an adapted ankle ergometer (OT Bioelettronica, Torino, IT). The force exerted by the dorsiflexor muscles of each leg was measured with a force transducer attached under the foot. High-density electromyography (HDsEMG) signals were recorded from the tibialis anterior muscle of each leg with a semi-resistant adhesive grid (yellow pad). Surface EMG recordings were also obtained from a pair of surface electrodes placed over the soleus and gastrocnemius medialis (green wires). The reference electrodes were placed at the wrist for the bipolar recordings and at the ankle for the grid (red wires). One goniometer was placed over each of the knee and the ankle joints to measure thejoint angle. Visual feedback was provided of the target force (red lines) and the applied force (blue lines) during the ramp-up, plateau, and ramp-down phases (middle screen) and on a moment-to-moment basis (right side of the screen). The display covered about 80% of the screen (Petrović et al., 2021)

2.4. Data processing and analysis

The dorsiflexion and plantar flexion forces were measured with a force transducer (200 kg; 2,001 mv/V, S/N 11406; TF022, CCT transducers) attached to the plate below the foot. The EMG signals from the left and right tibialis anterior were recorded using a semi-resistant adhesive 64 channel grid (5 × 13, 8 mm inter-electrode distance). The EMG signals from the left and right soleus and medial gastrocnemius were taken using bipolar surface electrodes (Thought Technology Ltd, CA) with an inter-electrode distance of 1 cm. According to SENIAM recommendations, the electrodes for soleus were placed at 2/3 of the line between the medial condyle of the femur to the medial malleolus, and the electrodes

for the medial gastrocnemius were placed over the most prominent bulge of the muscle (Hermens et al., 2000). The signals were acquired, amplified, band-pass filtered (-3dB bandwidth, 10-500 Hz), and digitized using a 12-bit A/D converter, using Quattrocento (OT Bioelettronica, IT) with a sampling frequency of 2048 Hz. The force applied by the foot was sampled at the same rate and synchronized with EMG recordings. The participants received verbal encouragement during all MVC trials. The greatest peak force was taken as maximum and used for further analysis. To quantify the activation of each muscle the Root Mean Square (RMS) of EMG recordings was computed during three seconds at the highest level. The RMS values of the plantar flexor muscles were summed to compute the overall RMS.

To determine the level of bilateral asymmetry, between the dominant and non-dominant leg, the absolute bilateral asymmetry index (ASI) was calculated: ASI (%) = [|XD - XND| / 0,5 * (XD + XND)] * 100 (Karamanidis et al., 2003), in which X is the measure of interest and D and ND refer to the dominant and non-dominant leg, respectively.

2.5. Statistical analysis

All statistical analyses were performed using the software package SPSS software (version 25, IBM, Chicago). The normality of the data was assessed with the one-sample Kolmogorov-Smirnov test in SPSS. To determine the differences between the lower limb MVC force and EMG-muscle activation, and the differences between ankle angles (DF 75°, 90°, 105° and PF 75°, 90°, 105°) in MVC force, a two-way repeated-measures ANOVA was used. Moreover, a Paired-Samples T Test on each dependent variable (MVC force and EMG) at different angles (DF 75°, 90°, 105° and PF 75°, 90°, 105°) was conducted as a follow-up test. In all measurements, statistical significance was set at the level of $p < 0.05$. Results are reported as mean and standard deviation (SD).

3. RESULTS

3.1. Legs Dominance

3.1.1. Maximal Voluntary Contraction Force

The analysis revealed a non-significant mean difference on MVC force, among the two independent variables, DF_{MVC} and PF_{MVC} as presented in Table 1. The non-significant differences between mean scores of dominances (DL and NL) and MVC force means of multiple angle groups implies that leg dominance had no effect on the multiple angle group's MVC force. Hence, it seems that MVC force is probably formed independently of leg dominance. Therefore, other factors need to be examined in order to investigate the exact leg dominance mechanism concerning MVC force.

Table 1 Differences in dorsal and plantar flexion between lower limb MVC force means for multiple angle groups

Variable	F	Effect - df	Error - df	p-value	ηp^2
DF_{MVC} 75, 90, 105	0.256	1	38	0.616	0.007
PF_{MVC} 75, 90, 105	0. 240	1	38	0.627	0.006

Legend: DF - dorsal flexion, PF - plantar flexion, MVC – maximum voluntary contraction. The significance levels: $p < 0.05$.

Furthermore, a Paired-Samples T Test, on each of the dependent variables (MVC force of DF 75°, 90°, 105° and MVC force of PF 75°, 90°, 105°) was conducted. As can be seen in Figure 2 A-B, all the results were non-statistically significant, $p > 0.05$. Therefore, the analysis reveals that there are similar levels of MVC force for dorsal- and plantar flexion at either 75°, 90°, or 105°, between the dominant and non-dominant leg of the sample.

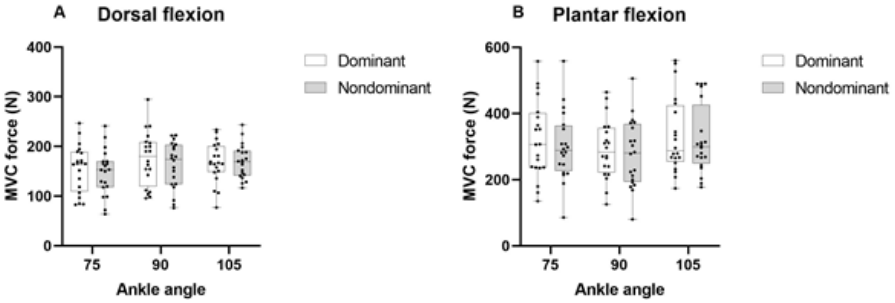

Fig. 2 A. Maximal voluntary contraction force developed between the dominant (open) and non-dominant (grey) leg during dorsiflexion at an ankle angle of 75°, 90°, and 105°. B. Maximal voluntary contraction force developed between dominant (open) and non-dominant (grey) leg during plantar flexion at an ankle angle of 75°, 90°, and 105°

Table 2 Differences in dorsal and plantar flexion between lower limb EMG-muscle activation means for multiple angle groups

Variable	F	Effect - df	Error - df	p-value	ηp^2
DF_{EMG} 75, 90, 105	0.241	1	38	0.904	0.006
PF_{EMG} 75, 90, 105	0.572	1	38	0.415	0.015

Legend: DF - dorsal flexion, PF - plantar flexion, EMG - electromyography.
The significance levels: $p < 0.05$.

3.1.2. Electromyographic Muscle Activation

The analysis revealed a non-significant mean difference on EMG-muscle activation, among the two independent variables, DF_{EMG} and $PF_{EMG,}$ as presented in Table 2.

Table 3 The % absolute asymmetry index (ASI) of the sample

Variables	ASI%
DF 75°	17.9 ± 16.2
DF 90°	25.8 ± 18.7
DF 105°	17.3 ± 13.9
PF 75°	18.4 ± 19.1
PF 90°	21.5 ± 15.4
PF 105°	17.1 ± 13.9

Legend: DF - dorsal flexion, PF - plantar flexion.

A Paired-Samples T Test, on each of the dependent variables (EMG of DF 75°, 90°, 105° and EMG of PF 75°, 90°, 105°) was calculated. All the results were non-statistically significant, $p > 0.05$. Therefore, the analysis reveals that there are similar levels of EMG

for dorsal- and plantar flexion at either 75°, 90°, or 105°, between the dominant and non-dominant leg of the sample as presented in Figure 3 A-B.

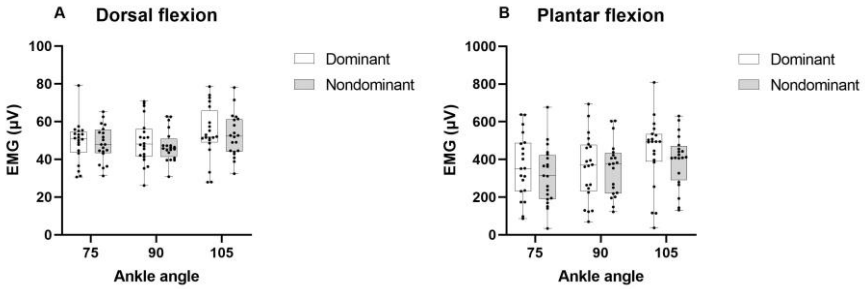

Fig. 3 A. Electromyography muscle activation developed between the dominant (open) and non-dominant (grey) leg during dorsiflexion at an ankle angle of 75°, 90°, and 105°. B. Electromyography muscle activation developed between the dominant (open) and non-dominant (grey) leg during plantar flexion at an ankle angle of 75°, 90°, and 105°

Specifically, the results showed that the EMG-muscle activation levels were similar between the dominant and non-dominant leg of the sample, although it seemed that the EMG-muscle activation of the non-dominant leg weakened in strength throughout repetitions, compared to the dominant leg. Therefore, further long-term studies on EMG-muscle activation need to be done, so as to explore the exact leg dominance mechanism concerning EMG-muscle activation over time.

3.1.3. Absolute symmetry index

The asymmetries observed during MVC of DF and PF ranged from 17.9 ± 16.2 to 25.8 ± 18.7 and from 17.1 ± 13.9 to 21.5 ± 15.4, respectively, as can be observed in Table 3. The ASI data do not indicate the appearance of asymmetry between the lower limbs.

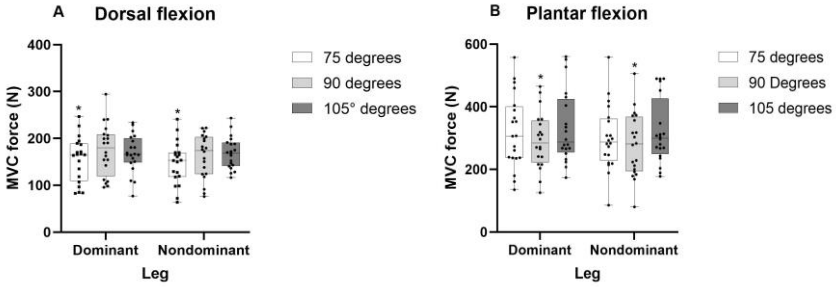

Fig. 4 A: Maximal voluntary contraction force developed during dorsiflexion at an ankle angle of 75° (open), 90° (grey), and 105° (dark grey), *: significantly less than 90° and 105°. B. Maximal voluntary contraction force developed during plantar flexion at an ankle angle of 75° (open), 90° (grey), and 105° (dark grey), *: significantly less than 75° and 105°

Table 4 Differences in dorsal and plantar flexion between three angles (75°, 90° and 105°) in MVC force

Variable	F	Effect - df	Error - df	p-value	ηp^2
DF_{MVC}	6.090	2	76	0.004	0.138
PF_{MVC}	9.752	2	76	0.000	0.204

Legend: DF - dorsal flexion, PF - plantar flexion, MVC – maximum voluntary contraction. The significance levels: $p < 0.05$.

3.2. Muscle length

3.2.1. Influence of muscle length on MVC force

The analysis revealed a significant influence of the ankle angle on MVC force for the dorsiflexors and the plantar flexors as presented in Table 4.

Table 5 Differences in dorsal and plantar flexion between three angles (75°, 90° and 105°) in EMG-muscle activation

Variable	F	Effect - df	Error - df	p-value	ηp^2
DF_{EMG}	5.455	2	76	0.006	0.126
PF_{EMG}	7.793	2	76	0.002	0.170

Legend: DF - dorsal flexion, PF - plantar flexion, EMG - electromyography. The significance levels: $p < 0.05$.

Furthermore, the MVC force for the dorsiflexors was at 75º (DL: 155.7 ± 47.8; NL: 147.9 ± 45.7 N) significantly less than 90º (p = .003; DL: 174.7 ± 54.5; NL: 161.9 ± 46.8 N) and 105º (p = .005; DL: 167.9 ± 40.5; NL: 169.1 ± 33.9 N), as can be seen in Figure 4A, and for plantar flexors at 90º (DL: 291.9 ± 90.0; NL: 278.2 ± 102.6 N) significantly less than 75º (p = .006; DL: 321.0 ± 116.6; NL: 300.4 ± 103.6 N) and 105º (p = .000; DL: 333.0 ± 115.7; NL: 321.0 ± 103.9 N), as can be seen in Figure 4 B.

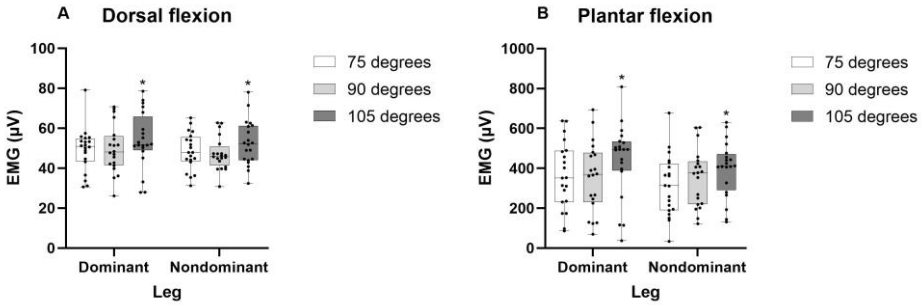

Fig. 5 A: Electromyography muscle activation developed during dorsiflexion at an ankle angle of 75° (open), 90° (grey), and 105° (dark grey), *: significantly less than 75° and 90°. B. Electromyography muscle activation developed during plantar flexion at an ankle angle of 75° (open), 90° (grey), and 105° (dark grey), *: significantly less than 75° and 90°

3.2.2. Influence of muscle length on EMG-muscle activation

The analysis revealed a significant influence of the ankle angle on EMG-muscle activation for the dorsiflexors and the plantar flexors as presented in Table 5.

Furthermore, EMG-muscle activation for the dorsiflexors was at 105º (DL: 54.0 ± 14.2; NL: 52.6 ± 11.4 N) significantly higher than 75º ($p = .013$; DL: 49.1 ± 10.9; NL: 48.5 ± 9.3 N) and 90º ($p = .003$; DL: 49.6 ± 12.1; NL: 47.2 ± 8.3 N), as can be seen in Figure 5A, and for plantar flexors at 105º (DL: 441.5 ± 186.6; NL: 397.1 ± 139.1 N) significantly higher than 75º ($p = .004$; DL: 364.1 ± 168.7; NL: 312.4 ± 153.3 N) and 90º ($p = .002$; DL: 364.2 ± 174.3; NL: 351.0 ± 144.7 N), as can be seen in Figure 4 B.

4. DISCUSSION

The primary findings of the study indicated similar levels of lower limb MVC force and EMG-muscle activation between dominant and non-dominant ankle muscles. These results are in agreement with earlier studies which also reported similar MVC forces of both dominant and non-dominant limbs (De Ruiter et al., 2010). Another finding was that the maximal force of dorsiflexors and plantar flexors is dependent on the changes in muscle length (Anderson, & Pandy, 2001). We examined the force in three different lengths (short, intermediate, and long) corresponding to the 3 ankle angles. From the analyzed data we can conclude that, as the muscle length increases, the maximal force also increases.

The findings of the present study support previous studies which indicated the absence of leg difference during ankle joint isometric MVC (Yen et al., 2018), the first dorsal interosseous MVC (Adam et al., 1998), force-matching tasks (Yamaguchi et al., 2019), and bilateral quiet standing (Wang, & Newell, 2014). In contrast, our results disagree with other researchers who reported that the dominant leg is significantly stronger than the non-dominant (Dalleau, Belli, Bourdin, & Lacour, 1998). These authors commented that leg differences in strength could be related to the dominant leg's propulsive function, while the non-dominant leg is more adaptive in balance control. At the same line, Õunpuu, & Winter (1989) reported significantly greater plantar flexor activation in the dominant than the non-dominant limb, indicating a larger neural drive to the dominant plantar flexors to generate the necessary propulsive locomotion power. These differences were detected using repeated and dynamics tasks which can be due to the activation of other muscles as well. It is important to mention that the mean scores of EMG-muscle activation in muscles were somewhat higher for the dominant than for the non-dominant leg, which might suggest that the influence of dominance may vary between individuals. Others have also reported an influence of dominance on recorded EMG frequency for the tibialis anterior and gastrocnemius medialis (Valderrabano et al., 2007), which also does not agree with our findings. The difference between our study and that of Valderrabano et al., 2007 could be due to the different age of the participants (32-65 yr, Average 53), as recent studies have shown that dorsal flexion muscles become weaker with a present between-leg imbalance in the elderly (Perry et al., 2007; Skelton et al., 2002). Collectively, within the limitations of the study we were unable to observed leg dominance effects.

As shown in Table 3, the presented data are in line with previous findings of an asymmetry of 18.3% observed in plantar flexors, but not in dorsiflexors (Valderrabano et al., 2007). Also, large asymmetry was confirmed in plantar flexion with the ASI mean ranging from 11% to 25% (Furlong, & Harrison, 2015). The results of our data confirmed such a difference in plantar flexors and also in dorsiflexors (mean ASI 17.1 – 21.5%, and

17.3 – 25.8%, respectively). These results are greater than the 15% previously reported as upper limit of asymmetry for healthy limb function in upper limbs (Knapik et al., 1991), and similar to 20% suggested as lower limb upper limit of asymmetry (Maulder, 2013). These normal to high ASI found in present research are a lot smaller than those previously found ASI of 45% in healthy subjects (Furlong, & Harrison, 2015) and 60% in injured cyclists (Bertucci et al., 2012). The present results point to the constraints imposed during performance of the task and timely tracking appearance of asymmetry and implement rehabilitation to avoid injuries that may occur, such as deformation of the Achilles tendon (Bohm et al., 2015), or tibial stress fractures (Finestone et al., 1991). Finally, ASI was smaller in the non-dominant leg in all angles of dorsiflexion and plantar flexion, which can be explained by its everyday use where the non-dominant leg mainly supports and stabilizes body posture during movements (Sadeghi et al., 2000).

The results of this study also showed the impact of muscle length on MVC dorsiflexors and plantar flexors strength (Table 4). These results confirm old (Bigland-Ritchie et al., 1992) and recent (Tsatsaki et al., 2021) research reports indicating that there is an influence of joint angles on dorsiflexion MVC force, as there were lower strength values at shorter lengths compared with longer length. Our results suggest a diminished force capacity of plantar flexors due to reduced excitation of the motor neuron pool when muscle length is decreased (Avancini et al., 2015; Miaki et al., 1999). EMG amplitudes are smaller for the gastrocnemii during plantar flexions performed with knee flexed compared to knee extended (Gandevia, & McKenzie, 1988). At a critical short length, the muscle is considered to be “actively insufficient”, and its motor neurons receive less net excitatory input (Kennedy, & Cresswell, 2001).

Overall, we found that dominance does not affect the maximal lower limb force and neural activation. Asymmetry between limbs may appear during submaximal contractions induced by the activation of the motor units (Adamo et al., 2012; Martin, & Adamo, 2011) but this issue remains open. The findings indicate that participants’ reports of preferred footedness were not associated with differences in the functional characteristics of the dorsiflexor and plantar flexor muscles during isometric contractions. The suggested 20% for normal between-limb function has to be analyzed further, and not be taken as the strict risk border line.

The disagreement between various findings on the effects of dominance on lower limb strength and activation suggests that further research is required to investigate the exact mechanism of leg dominance function. Our results suggest that dominance evaluation has limited importance for the evaluation of maximal voluntary contraction force and electromyography muscle activation, at least for these experimental settings.

5. CONCLUSION

In conclusion, the present study suggests that leg dominance has no effect on lower limb maximal voluntary contraction and neural activation. Within this study limitations, it appears that in healthy individuals there are no apparent effects of dominance on plantar flexor and dorsiflexor maximal strength. Large differences in strength between the legs may, therefore, accompany pathological conditions, although, clearly, more research is required in this direction.

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MODIFIKACIJE MAKSIMALNE SILE I NEURALNE AKTIVACIJE MIŠIĆA GLEŽNJA U ZAVISNOSTI OD DOMINANTNOG EKSTREMITETA

Cilj istraživanja bio je da se procene razlike između maksimalne voljne kontrakcije donjih ekstremiteta (MVC) i neuronske aktivacije na osnovu dominantne noge. Dvadeset aktivnih ispitanika sa dominantnom desnom nogom (starost: 31,3 ± 9,5 godina, visina: 178,2 ± 7,6 cm, težina: 76,5 ± 11,0 kg) izvelo je 3 maksimalne dorzalne fleksije (DF) i plantarne fleksije (PF) pod 3 ugla skočnog zgloba (75 °, 90 °: anatomski položaj i 105 °), što odgovara kratkim, srednjim i većim dužinama za DF mišiće, a suprotno za PF mišiće. Elektromiografija (EMG) je korišćena za procenu aktivnosti mišića skočnog zgloba (tibialis anterior, gastrocnemius medialis i soleus). Rezultati su pokazali neznatne razlike između MVC sile donjih ekstremiteta i aktivacije EMG mišića. Međutim, primećen je značajan glavni efekat ugla. Tokom DF, MVC sila je bila veća ($p < 0,05$) na 90° i 105° nego na 75° za obe noge i tokom PF, MVC sila je bila veća ($p < 0,05$) na 75° i 105° nego na 90° za obe noge. Štaviše, tokom DF i PF, aktivacija EMG mišića bila je veća ($p < 0,05$) na 105° nego na 75° i 90° za obe noge. Rezultati pokazuju da dominantna noga nije bila povezana sa različitim nivoom sile i neuronske aktivacije tokom maksimalne dobrovoljne kontrakcije mišića skočnog zgloba. Zaključeno je da dominantna noga nema uticaja na maksimalnu silu i neuralnu aktivaciju mišića skočnog zgloba i da bilo kakvi mehanizmi koji doprinose efektu dominacije ekstremiteta nisu evidentni na primeru ovog eksperimentalnog protokola.

Ključne reči: *Dominantna noga, maksimalna voljna kontrakcija, elektromiografija, ne-dominantna noga, sila, donji ekstremiteti*

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Research article

THE EFFECT OF DIFFERENT EXERCISE PROGRAMS ON MOTOR ABILITIES IN PRIMARY SCHOOL CHILDREN

UDC 796.012.1-053.5

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Abstract. *The aim of this study was to determine and to compare the effects of different exercise programs on motor abilities in primary school children. A total of 60 (30 boys and 30 girls) primary school children, aged 12 years ± 6 months voluntarily participated in this study. Motor abilities were assessed by the following variables: the squat jump, long jump, bent-arm hang, sit-ups, push-ups, sprint 30m, T-test, handgrip, and medicine ball throw tests. All groups had regular physical education classes twice a week and one hour of additional physical activity, with the experimental groups exercising with a medicine ball (E1) following a developmental gymnastics program (E2) during the 12 weeks. The ANCOVA showed statistically significant differences between the groups ($p<0.05$) in most motor abilities tests in favor of both experimental groups, with slightly better results in favor of the E1 group compared to E2. The results of this research show that exercise with a medicine ball and developmental gymnastics can lead to significant improvements in motor abilities among primary school children.*

Key words: *exercise, physical activity, medicine ball, developmental gymnastics*

INTRODUCTION

Physical education is the only subject in the school curriculum that concentrates on the physical, mental and social development of adolescents together. Moreover, it stimulates them for a healthy lifestyle, in which physical fitness, in addition to nutrition, also has a primary role (Džakula, Miljković, Pavičić, & Banjac, 2020). The variety of elements of preparation and its realization in practice characterizes the teaching of PE the world over. Despite so much

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diversity, the teaching of physical education in different educational systems is characterized by a common goal, and that goal is to advocate for the process of physical education that contributes to the development of the individual (Hardman, 2009). The main goal of teaching physical education is that the desired transformations of the anthropological status of school children are in the function of satisfying the need for movement, of contributing to the increase in adaptive and creative skills in modern living and working conditions, and of preserving health and creating a lasting habit of physical activity, which should be accepted as a need that contributes to health culture and improves overall lifestyle (Najšteter, 1997). Physical education has a very important share in the education of the individual, and aims to contribute to the optimal development of the individual through physical activities as well as the growth and development of his physical abilities and psychosocial characteristics (Hardman, 2007).

During adolescence, muscle fitness is a significant indicator of future health (Ortega, Ruiz, Castillo, & Sjöström, 2008; Ruiz et al., 2009). Although they have beneficial effects on health, physical fitness trends have an annual decline of 2% (Cadenas-Sánchez, Artero, Concha, Leyton, & Cain, 2015). Modern fitness programs, especially exercise programs with loads on equipment and props such as medicine balls and developmental gymnastics programs, have positive effects on school children's health and motor abilities that are necessary for performing a large number of daily activities (Smith et al., 2014).

Although there are various safe and effective forms of equipment, medicine balls have become very popular in schools, gyms, fitness centers and sports training facilities (Faigenbaum & Mediate, 2008). The most important benefit of exercising with a medicine ball is that it affects the whole body instead of its individual segments. In addition, a medicine ball provides a unique type and number of exercises with unlimited intensity that can be used. Faigenbaum & Mediate (2006) have also shown that training with a medicine ball can be an effective method of improving the motor abilities of school-age children during PE classes.

Exercising with equipment and on the floor, as a type of developmental gymnastics, is very rich in a variety of movements and positions. The richness of movement and position during training on apparatus and floor enables the trainee to create a high level of motor knowledge. This knowledge, along with good physical condition and health enables a person to have a better quality of life. In addition, a high level of motor knowledge is a very good basis for engaging in any sport (Madić & Popović, 2012).

Recent studies show that medicine ball training has benefits for physical fitness (Trajković, Madić, Andrašić, Milanović, & Radanović, 2017; Boyaci & Afyon, 2017), self-perceived and actual motor competence (Duncan, Jones, O'Brien, Barnett, & Eyre, 2018), working memory (Jansen, Scheer, & Zayed, 2019), as well as acute cardio metabolic responses (Faigenbaum et al., 2018) in children. Contrary to the abovementioned studies, one study showed non-significant improvements in 1RM chest press strength as compared to the control group (Faigenbaum et al., 2007). With that being said, more school-based interventions concerning medicine ball training are needed. Moreover, some studies also showed that developmental gymnastics causes positive effects on the development of motor abilities in primary school children in relation to the current regular PE curriculum (Aleksic, Mekic, & Tosic, 2011; Paunović, 2017).

Since there are no studies that directly compared the abovementioned types of strength programs, the aim of this study was to compare the effects of medicine ball training, developmental gymnastics, and regular physical education programs on motor abilities in primary school children.

METHOD

Sample of participants

The sample for this research was taken from the population of 7th grade children of the primary school "Pale" from Pale, aged 12 years ±6 months. A total of 60 participants (30 boys and 30 girls) were randomly divided into 3 groups: the first experimental group (E1) (n = 20), second experimental group (E2) (n = 20), and the control group (K) (n = 20). All participants were completely healthy on the days of testing and were not exempt from physical education classes. In addition, they all had the consent of their parents. For the final data processing, only those participants were included who participated in both the initial and final measurements. The basic descriptive data are presented in Table 1.

Table 1 Descriptive characteristics of the participants

Variable	E1	E2	K
Body height	165.4 ± 6.1	161.1 ± 4.1	160.9 ± 5.9
Body mass	54.7 ± 5.5	52.2 ± 5.1	52.8 ± 7.3
BMI	19.9 ± 1.5	20.1 ± 1.5	20.3 ± 2.2

BMI – body mass index

Procedure

Measurement of motor abilities was performed immediately before the beginning of the experimental treatment, and after 12 weeks. All measurements were conducted on the sports fields of the primary school "Pale" from Pale. The participants came in groups of 10 to 20 and during the measurement they were trained in using sports equipment for physical education classes.

All measurements were performed with the same measuring instruments. Also, the same measurement techniques were applied at the initial and final measurements. The measurement was performed by assistants at the Faculty of Physical Education and Sports. To avoid a daily impact on performance, all tests were performed at the same time of day, according to standardized protocols and in accordance with the recommendations of the equipment manufacturers and equipment used. The sample of measuring instruments consisted of: the squat jump, long jump, bent-arm hang, sit-ups, push-ups, sprint 30m, T-test, handgrip, overhead medicine ball throw forwards (MBT1), overhead medicine ball throw backwards (MBT2), and medicine ball supine overhead throw (MBT3).

Description of Motor Abilities Assessment

The squat jump

The participant stands in the position of legs bent at the knees at an angle of 90°, feet hip-width apart, arms to the sides. From the initial position, the participant jumps as much as possible and lands on the ground with both feet at the same time. The parameter of explosive power of the legs, which was obtained with the help of the Optojump device, and which was statistically processed, is: jump height (in cm) (Harman, Rosenstein, Frykman, & Rosenstain, 1990).

The long jump

The participant is in a shoulder-width apart position, face facing the expert, fingertips placed just behind the line. With a strong swing of the arms and a takeoff forward, the maximum long jump is performed. From the initial position, the respondent jumps as much

as possible, and the better result from two attempts is graded, and expressed in centimeters (Erkmen, Taşkin, Sanioğlu, Kaplan, & Baştürk, 2010).

The bent-arm hang

The participant tries to endure as much as possible with arms outstretched hanging from a bar. The time spent by the participant hanging with arms bent is measured, and the result is entered in seconds (Sudarov & Fratrić, 2010).

Push-ups

The participant occupies a plank position, straight legs and feet slightly apart. The participant pushes against the floor until the arms are straight at the elbows, the legs, and back are extended. The back should be kept in a straight line from head to toes throughout the body. The participant then lowers the body using the arms until they are bent at an angle of 90 degrees and the upper arms are parallel to the ground. This movement is repeated as many times as possible (Castro-Piñero et al., 2009).

Sit-ups

The participant lies on his back, knees bent, arms bent and fingers crossed at the nape of the neck. He then lifts his torso until his chest reaches his knees and his assistant holds his feet firmly. The number of correct runs in 60 seconds is entered (Castro-Piñero et al., 2009).

Sprint 30m

The participant starts from a high start at the moment when he estimates that he is ready and sprints over the entire 30m course. The time from start to finish is measured. The time is read in a 1/100s by an electronic timekeeping system with photocells (MICROGATE) set at 30m (Sudarov & Fratrić, 2010).

The T-test

Three cones are placed in the same plane at a distance of 4.57 meters. The starting line is perpendicular to the middle cone and 9.14 meters away. The task is to cross the path between the four bases (A, B, C and D) placed in the shape of the letter T in the shortest possible time. The participant at the start has both feet behind the starting line. From the start line, the participant runs towards the middle cone (B) and touches it with his right hand, then moves sideways to the left cone (C) which he touches with his left hand. He then moves sideways to the right cone (D) which he touches with his right hand and then returns laterally to the middle cone (B) which he touches with his left hand and finally returns inwards to the starting line (A). Timing begins and ends at base A. When moving sideways, he does not cross his legs. The test is performed three times (with a sufficient break between repetitions), one of which is a trial attempt and then run two more times, taking into account the better result for statistical processing (Sudarov & Fratrić, 2010).

Handgrip

The participant is in a smaller stride position, the hand with which he performs the grip is bent at the elbow at an angle of 90 °. The participant squeezes the dynamometer as hard as possible at the examiner's signal, and the task is completed after the examiner reads the result. The result is the value read on the dynamometer scale. The task is performed 2 times (Sudarov & Fratrić, 2010).

Overhead medicine ball throw forwards (MBT1)

The test is performed indoors or outdoors on an area with minimum dimensions of 25x10 m. A line is drawn in the middle of one end of the shorter part of the spatial rectangle,

which is also the initial line for measuring the throw. The participant is in a parallel, slightly outstretched position in front, facing in the direction of the throw. With the technique used to throw in football, he throws out the medicine ball in order to achieve the best possible result. The participant is allowed to cross the line after the throw. The evaluation is performed in all units of length by marking the place of landing of the medicine ball, and measuring the distance from the starting line to that place. Three attempts are recorded, and the best of all is entered (Sudarov & Fratrić, 2010).

Overhead medicine ball throw backwards (MBT2)

To perform this test, a sports hall or an outdoor space with minimum dimensions of 25x10 m is required. In the middle of the shorter part of the space, a line is drawn behind which the participant stands and from which the ejection is measured. The participant is in a stride stance position behind the line marked on the test area by facing the opposite direction of the medicine ball throw. He holds the medicine ball with his hand on one side at knee height. From that position, he makes a strong swing backwards and over his head, after which he throws the medicine ball in the opposite direction. He is entitled to one trial and two attempts, between which he uses a 30-second break. Evaluation is done by recording the best of all attempts. The measurement is performed from the ejection line to the place where the medicine ball made contact with the surface (Sudarov & Fratrić, 2010).

Medicine ball supine overhead throw (MBT3)

The task is performed in a sports hall or outdoors. The mat is placed so that its narrower edge touches the narrower edge of the spatial rectangle. In the middle of the line where the sides of the spatial rectangle and the mat meet, a zero point and a medicine ball are placed. From this place, a straight line is drawn with chalk on which the measuring tape is placed. The participant is in a supine position with his hips wide, lying on a mat with legs slightly apart, facing the measuring tape. When throwing, he uses the technique of the throw in football, by holding the medicine ball and making a strong swing, after which he throws the ball as far as possible, without raising his head and torso. The participant performs this throwing procedure four times. The distance from the zero point to the place where the medicine ball fell is measured, and the best of four throwing results is entered (Sudarov & Fratrić, 2010).

Experimental procedure

This research is a pre-post treatment (12 weeks), realized on the sports fields of the elementary school "Pale" from Pale (East Sarajevo).

Experimental group (E1) had three classes a week in which two regular physical education classes were conducted according to the curriculum for primary education and upbringing prescribed by the Ministry of Education and Culture of the Republic of Srpska "Official Gazette of the Republic of Srpska - No. 74" (2014) and one class of additional physical activity where the exercise with the medicine ball was described in detail in Table 1. Each class consisted of a four-part structure, a warm-up period with medicine ball games (5 minutes), a preparatory part where shaping exercises and exercises for raising the level of motor abilities were performed (10 minutes), a the main part of the class (25 minutes) where exercise with medicine balls was realized, Table 1, And the cool down period of lowering intensity and stretching (5 minutes).

Experimental group (E2) had two classes a week conducted according to the curriculum for primary education and upbringing prescribed by the Ministry of Education and Culture of the Republic of Srpska "Official Gazette of the Republic of Srpska - No. 74" (2014) and one class of additional physical activity where the developmental gymnastics program was

realized. Each class consisted of a four-part structure, a warm-up period (5 minutes), a preparatory part where shaping exercises and exercises for raising the level of motor abilities were performed (10 minutes), the main part of the class (25 minutes) where developmental gymnastics compositions were processed: floor exercises, vault, pommel horse, still rings, uneven bars, horizontal bar, balance beam, and a cool down period of lowering intensity and stretching (5 minutes). After the experimental program, the final measurement of the control and experimental groups was performed.

The control group (K) had two regular PE classes per week (gymnastics and explosive strength exercise were not included) according to the curriculum for primary education.

Table 2 Exercise program plan with a medicine ball

Exercise plan 1-3 weeks		
Name of exercise	Series number	Number of repetitions
Throwing a medicine ball over your head	3	10
Jumps with a medicine ball	3	12
Throwing a medicine ball with a turn *	3	10
Adding medicine ball from the chest	3	10
Lateral jumps over the medicine ball	3	20
Throwing the medicine ball backwards by rotation *	3	10
Exercise plan 4-6 weeks		
Lateral addition of breast medicine ball *	3	12
Burpee with a medicine ball	3	12
Diagonal throwing of the medicine ball back *	3	8
Throwing the medicine ball upwards from a squat	3	10
Diagonal throw of the medicine ball from the floor *	3	10
Star jumps	3	15
Exercise plan 7-9 weeks		
Push-ups through medicine ball	3	18
Squat jumps with a medicine ball throw	4	8
Diagonal throw of the medicine ball from the floor *	3	8
Depth jumps	3	8
Throwing a medicine ball over your head with a step	4	10
Throwing a medicine ball through your legs	3	10
Exercise plan 10-12 weeks		
Squat jumps with a medicine ball throw	4	8
Push-ups through medicine ball	4	14
A combination of chest jumps and deep jumps	4	8
Throwing the medicine ball backwards with a jump	4	8
Lateral jumps over the medicine ball	4	12
Throwing a medicine ball out of a squat	4	8

Exercises marked with an asterisk (*) are done on both sides (left and right hand)

Statistical analysis

The normality of the distribution was determined by the Kolmogorov-Smirnov test. To determine the significance of differences between the control and experimental groups in the initial testing, a univariate analysis of variance (ANOVA) was used. An analysis of covariance (ANCOVA) was used to evaluate intervention effects. Additionally, Cohen's d effect sizes (ES) were also calculated to determine the magnitude of the group differences in motor abilities. The significance level was set at $p<0.05$. The data obtained by the previously described procedure were processed in the statistical package SPSS 20. (Statictical Package for Social Science, v20.0, SPSS Inc., Chicago, IL, USA).

RESULTS

The results of the Kolmogorov-Smirnov test are below the limit value of max.d = 0.231, for a sample of 20 participants at the level of statistical significance (p>0.20) (Facchinetti, 2009), and thus confirm the normality of the distribution of the results in all variables.

Table 3 Differences between groups in motor abilities - ANCOVA

Variables	Initial E1	Final E1	ES	Initial E2	Finl E2	ES	Initial K	Final K	ES	p
Squat jump	22.1± 6.0	24.3± 6.0	0.4	20.1± 4.6	21.6± 4.4	0.3	20.6± 5.7	20.7± 5.7	0.0	0.09
Long jump	169.4±28.5	175.6±26.1	0.2	156.8±19.1	161.7±17.9	0.2	158.8±27.0	161.0±26.3	0.1	0.08
Bent-arm hang	36.7±16.5	42.7±16.5*	0.4	31.8±11.5	37.0±11.4	0.4	30.5±12.0	31.7±12.2	0.2	**0.01***
Sit-ups	21.7± 4.8	26.0± 5.2	0.8	21.7± 4.4	26.1± 4.9	0.9	21.2± 3.4	21.9±3.5†	0.2	**0.01***
Push-ups	14.3±10.0	18.8±10.4	0.4	14.0± 9.8	17.3±10.2	0.3	11.7± 7.5	12.0±7.6†	0.1	**0.01***
Sprint 30m	5.9± 0.5	5.8± 0.5	0.2	5.8± 0.3	5.7± 0.3	0.3	5.9± .5	5.9± 0.5	0.1	0.45
T-test	15.7± 1.8	14.6± 1.7	0.6	15.6± 1.3	14.4± 1.2	0.9	15.8± 1.7	15.7±1.6†	0.1	**0.01***
Handgrip	20.3± 4.0	22.7± 3.9	0.6	19.5± 4.4	21.5± 4.1	0.4	20.1± 3.1	20.4± 3.0	0.1	**0.02***
MBT1	6.4± 0.7	6.9±0.7*	0.7	6.3± 0.6	6.4± 0.6	0.1	6.2± 0.5	6.2± 0.5	0.1	**0.01***
MBT2	6.0± 0.6	6.5±0.6*	0.8	5.8± 0.5	5.9± 0.5	0.2	5.8± 0.4	5.8± 0.4	0.1	**0.01***
MBT3	4.6± 0.2	5.1±0.3*	1.9	4.5± 0.2	4.6± 0.2	0.5	4.5± 0.2	4.6± 0.2	0.5	**0.01***

*- E1 significantly different from E2 and K; † - K significantly different from E1 and E2; ES – effect size

The results of the ANOVA showed that there were no statistically significant differences between groups at the initial measurement (p>0.05). The ANCOVA showed that there were statistically significant differences in the effects of the intervention program between the groups for the bent – arm hang (p=0.01), sit ups (p=0.01), push – ups (p=0.01), T-test (p=0.01), handgrip (p=0.02), MBT1 (p=0.01), MBT2 (p=0.01), and MBT3 (p=0.01). The Post Hoc analysis showed that the E1 group had better results for the bent – arm hang, MBT1, MBT2, MBT3 compared to the E2 and K group. Moreover, the E1 and E2 groups had statistically better results compared to the K group in variables: sit ups, push ups, T-test and handgrip strength. Furthermore, higher effect size was found in E1 (from 0.2 to 1.96), compared to E2 (from 0.33 to 0.96) and the K group (from 0.04 to 0.20).

DISCUSSION

The main goal of this study was to determine and to compare the effects of different exercise programs (exercise program with a medicine ball and a developmental gymnastics program), which was applied as additional physical activity for 12 weeks, on primary school children's motor abilities. The primary findings of this research are that the experimental treatments have brought greater improvement in motor abilities than traditional PE classes. These results show that certain exercise programs with medicine ball and the program of developmental gymnastics, as an entire part of the process of teaching PE, can be considered very useful for improving the motor abilities of primary school children. Several studies involving this population noticed improvements in some motor abilities parameters (Trajković, Madić, Sporiš, Aleksic-Velkovic, & Zivcic-Markovic, 2016; Paunović, 2017; Trajkovic, Madic, Andrasic, Milanovic, & Radanovic, 2017; Durmo et al., 2020; Pržulj et al., 2020). According to Falk & Tenebaum (1996), primary school children can increase strength by up to 50% during the first 8 weeks of exercise. The results from this research can be compared with these results because exercise with medicine ball and developmental gymnastics proved to be very good for the development of motor abilities of primary school children.

An emerging body of evidence increasingly supports the need for school-age youth to improve their strength and enhance their motor abilities performance (Artero et al., 2014; Hardy et al., 2012; Ortega et al., 2012). As part of comprehensive school physical activity guidelines, the inclusion of these activities demonstrates the importance of this type of intervention for all youth (SHAPE, 2014). Furthermore, the difference between children with higher and lower motor abilities competence seem to remain stable over time (Fransen et al., 2014). Given that physical activity declines rapidly after puberty (Whitt-Glover et al., 2009), the mentioned program specifically targets exercise deficits in school-age children, so children should begin with activities early in life before they become resistant to targeted interventions (Faigenbaum et al., 2015).

Compared to the initial results, there was a significant improvement ($p < 0.05$) in all tests of motor abilities. Faigenbaum & Mediate (2006) stated that exercising with a medicine ball can be a very effective method for improving motor abilities of school children during physical education classes. Related studies (Trajković et al., 2017; Pržulj et al., 2020) involving the same population lasting 12 weeks showed an improvement in motor abilities, so increases observed in this study were consistent with the expected results.

Trajković et al. (2016) have found improvement in motor abilities of school children who were included in the gymnastics program. The authors found improvements in all tests ($p < 0.05$), except in the 4x10m test. The results from our study show that there was a significant improvement in the bent-arm hang, sit-ups, push-ups, t-test and handgrip tests in both experimental groups compared to the control group. However, the group that practiced with a medicine ball achieved significantly better results in the throwing tests of the medicine ball compared to the developmental gymnastics program and control group ($p = 0.001$).

Faigenbaum et al. (2018) had a similar structure of the medicine ball training protocol, which was mixed, because different abilities or combinations could be characterized as moderate to vigorous (Hollis et al., 2016), depending on the needs, goals and the abilities of the participants. This adds variety to the program and reflects how children may actually perform these abilities at school.

The Faigenbaum et al. (2007) study is very similar to ours, since they also had an additional training program. Although both studies included motor abilities, our medicine ball exercises were likely incorporated into the developmental gymnastics program, same as their resistance training was likely incorporated with their plyometric training. With that being said, the results are in accordance with findings of Vossen et al. (2000) who noted that the addition of upper body training may increase the ability to improve whole body performance and motor abilities.

A new finding from this research is that the introduction of exercise with a medicine ball, or developmental gymnastics at least once a week results in better physical fitness results than is usually achieved with standard physical education classes for children. Since all three groups participated in the same traditional physical education classes at school, such differences in motor abilities are probably due to specific training adjustments that resulted from medicine ball exercises, as well as developmental gymnastics programs.

CONCLUSION

The results of this research indicate that exercise with a medicine ball and a developmental gymnastics program can result in significant improvements in selected components of children's motor abilities, and are an effective method for promoting physical activity in school children

and youth in general. Exercising with a medicine ball resulted in significantly greater improvements in motor abilities than the program of developmental gymnastics, as well as traditional physical education classes. Future studies should focus on including such programs in PE classes and potential differences in exercise intensity, as well as the long-term effects of childhood exercise with a medicine ball and developmental gymnastics on physical activity habits and health-related conditions.

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EFEKTI RAZLIČITIH PROGRAMA VEŽBANJA NA MOTORIČKE SPOSOBNOSTI UČENIKA

Cilj ovog istraživanja bio je da se utvrdi i uporedi uticaj različitih programa vežbanja na motoričke sposobnosti djece osnovnoškolskog uzrasta. Ukupno 60 (30 dečaka i 30 devojčica) dece osnovnovno školskog uzrasta, uzrasta 12 godina ± 6 meseci je dobrovoljno učestvovalo u ovoj studiji. Motoričke sposobnosti su procenjivane sledećim varijablama: skok iz čučnja, skok udalj, izdržaj u zgibu, podizanje trupa, sklekovi, sprint 30m, T-test, stisak šakom i testovi bacanja medicinke. Sve grupe su imale redovnu nastavu fizičkog vaspitanja dva puta nedeljno i po jedan čas sekcije, a eksperimentalne grupe su imale vežbe sa medicinkom (E1) i program razvojne gimnastike (E2) tokom 12 nedelja na času sekcije. ANCOVA je pokazala statistički značajne razlike između grupa ($p<0.05$) u većini testova motoričkih sposobnosti u korist obe eksperimentalne grupe, sa nešto boljim rezultatima u korist E1 grupe u odnosu na E2. Rezultati ovog istraživanja pokazuju da vežbanje sa medicinkama i razvojna gimnastika mogu dovesti do značajnog poboljšanja motoričkih sposobnosti kod dece osnovnoškolskog uzrasta.

Ključne riječi: *vežbanje, fizička aktivnost, medicinka, razvojna gimnastika*

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Research article

BODY COMPOSITION AND NUTRITIONAL STATUS OF PRESCHOOL CHILDREN

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Abstract. *The main goal of this research was to determine gender-related differences in some parameters of body composition caused by the nutritional status of preschool children, and group differences within subsamples caused by the nutritional status of both genders. The total sample consisted of 188 participants, boys (n=107) and girls (n=81) from Belgrade, with average values of body height BH=124.59cm±5.76 and body mass BM=24.32kg±3.11, average age 6.39±0.44 years. Body composition was assessed using the InBody 230 device. The main parameters of descriptive statistics were calculated. The MANOVA method was used to determine gender differences in the entire sample, and the ANOVA method was used to determine individual differences. A series of Post-Hoc Bonferroni tests were performed to determine between which groups significant statistical differences existed. This study provides encouraging findings when it comes to a satisfactory percentage of normally nourished children of both genders, but it should also point to a certain trend in the rise of obese and overweight children who make up almost 17% of the total sample. The differences observed in the girls' subsample may indicate girls enter the pre-pubertal phase earlier than boys, based on the differences in the amount of body fat tissue, but also always greater muscle mass in the boys' subsample, and lower average values of body mass and the Body Mass Index in the girls' subsample. Constant monitoring of children's nutritional status and physical abilities every six months or once a year is recommended.*

Key words: *Body Mass Index, Body Composition, Gender and Group Differences, Preschool Age*

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INTRODUCTION

The fact that the body structure is a clear characteristic and that in the case of people it represents human behaviour, disease, and that during the preschool age it is studied from the aspect of growth and development, and not from the aspect of defining body constitution. This is because the level of development of preschool-age children is uneven and therefore constant monitoring of the anthropological dimensions of preschool children, from the youngest age to school age, is very important.

Morphological characteristics provide findings on the psychosomatic status of man, which is defined by anthropometric measurements of the body as a whole or its parts, on the basis of which an objective picture of man's physical development can be obtained (Bala & Popović, 2007). In our region, for the first time, a hierarchical structure of morphological dimensions has been established for school children (Momirović, Medved, Horvat, & Pavišić-Medved, 1968), and since then, studies have mostly been based on their reduced models (Bala, 2007; Pelemiš, Prskalo, & Madić, 2019). Four decades ago, other methods for estimating body composition and determining the structure of morphological space began to be used worldwide, not based on the factor model but rather based on the estimation of body parameters by using methods such as plethysmography, hydrodensitometry, bioelectric impedance (BIA) (Karaba-Jakovljević, 2016). By comparing some of these methods, differences also emerge in attitudes about their use among different authors. An even earlier belief indicates that the BIA method is more useful than others because it provides results at the level of the whole body (Heinonen, Oja, Sievanen, Pasanen, & Vuori, 1998), but the assessment in the sample of older participants must be taken into account as well. Contrary to this fact, a group of authors including Eisenmann, Heelan, & Welk, (2004) indicate that the BIA method has limited application in children aged between 3 and 8. However, it can be said that basic anthropometric measure for designating constitution kind are still more present than the BIA method (Pelemiš, Ujsasi, Srdić, Džinović, & Pavlović, 2019), which could not be assumed given the ease of estimating body composition parameters. This fact probably indicates the deficiencies of the BIA method compared to others, although there are no significant papers that indicate the validity of the parameters obtained by using the BIA method. Today, we also come across terms such as *morphological condition*, which includes indicators of obesity, which include: the Body Mass Index (BMI), visceral and subcutaneous abdominal fat and waist size (Malina & Katzmarzyk, 2006). The authors point out the weaknesses of BMI parameters, which can be explained by the fact that morphological indicators and elements of body composition are not observed separately and individually, but rather together. There is also study by Musalek and associates (2017) that denies this, but also points out that indices such as BMI are not able to identify the amount of adipose tissue that is crucial in assessing motor skills, but only the nutritional status of the population.

After the review of the findings of previous research, the deficiency in the studies of a similar nature conducted so far is reflected in the insufficient number of findings that are supposed to indicate whether and to what extent nutritional status affects possible differences in body composition. Therefore, this research can help us to know something new and additional regarding questions of whether the nutritional status of preschool children of both genders can cause group differences in their body composition, and which of the body composition parameters is the most prominent from the aspect of these group differences. In the preschool age, this could indicate which gender and which nutritional

status group enters the pre-pubertal phase earlier, especially if a subsample of normally nourished children is observed.

The aim of this study was to determine if there are gender-related differences in preschool children in body composition when their nutritional status is neglected, and group differences within subsamples caused by the nutritional status of both genders.

METHOD

The research was of a transversal nature. Was used an ex post facto draft in the research. From the aspect of the scientific research type, the empirical research method was used, while the confirmatory analytical method was used to analyse the problem. The total sample included 188 participants, on average 6.39±0.44 years of age. Of these, 107 were boys or 56.91% of the total sample who were on average 6.44±0.50 years of age, with average body height, body mass and BMI (BH=124.42±5.66 cm; BM=24.77±2.82 kg, BMI=16.03±1.72 kg/m^2), and 81 were girls or 43.09% of the total sample, mean age 6.34±0.35 and mean values of height, body mass and BMI (BH=124.77±5.87cm; BM=23.88±3.35 kg; BMI=15.35±1.93 kg/m^2), who attended the preschool institution "PU Čukarica" in Belgrade (Republic of Serbia). Before the start of the study (October 2019), the children's parents/guardians provided written permission for their children to take part in the research (World Medical Association Declaration of Helsinki, 2013).

Anthropometric measurements were chosen as the sample of measurement instruments: 1. For Longitudinal Skeletal Dimensionality: 1) *Body height* (0.1 cm); 2. For body volume and mass: 2) *Body mass* (0.1 kg). Based on these two dimensions measured, 3) *BMI* (kg/m^2) was calculated too, according to the classification prescribed by the World Health Organization (2008):

$$\text{Body Mass Index}=\text{Body Mass}/\text{Body Height}^2$$

The participants were further grouped based on their BMI by the Centres for Disease Control and Prevention (2000) into the following subsamples: 1) ≤5 percentile- malnourished; 2) between 5 and 85 normally nourished; 3) between 85.01 and 95 overweight and 4) over 95.01 obese.

Body composition was assessed using three body composition measures, as follows: 4) *Muscle mass percentage* (0.1 kg); 5) *Body fat percentage* (0.1 kg) and 6) *Body Water Percentage* (0.1 kg).

The Martin anthropometer was used to measure body height. The participants had no shoes on. They stood on a flat surface, heels together, head in the "Frankfurt horizontal" position. The result is expressed in values of 0.1 cm. Body mass was measured with InBody 230 (Biospace Co., Ltd, Seoul, Korea). The participants stood on the device dressed only in their underwear. The result is expressed in values of 0.1 kg. Body composition measurement was also done by using the Inbody 230 device, which operates based on the BIA methodology.

SPSS software version 20 was used for data analysis. Descriptive statistics were calculated: the measures of central tendency AM-arithmetic mean; and variability measures of S-standard deviation. The normality of data distribution was calculated using the Kolmogorov-Smirnov KS-normality test. Furthermore, four categories of participants according to percentiles were obtained: malnourished; normally nourished; overweight and obese. The MANOVA method was used to determine gender differences in the entire

sample, and a One-Way analysis of variance method was used to determine individual differences. After significant differences were determined between groups of participants obtained on the basis of nutritional status, a series of Post-Hoc Bonferroni tests were performed to determine between which groups significant statistical differences existed.

RESULTS

As shown in table 1, the sample was further grouped based on BMI reference values, and according to the percentile values into the following subsamples (as mentioned above): 1) ≤5 percentile- malnourished; 2) between 5 and 85 normally nourished, 3) between 85.01 and 95 overweight and 4) over 95.01 obese.

It can be seen from Table 1 that the malnourished part of the sample is represented by 10.64%; normally nourished 72.34%; overweight 9.57% and obese 7.44%. Furthermore, a somewhat clearer picture was obtained after dividing the total sample by gender. The values shown in table 1 indicated that the percentage of malnourished boys was 9.35%, normally nourished boys 71.03%, overweight 12.15%, and obese only 7.47%. When looking at the values for girls, we can see that malnourished girls is slightly higher than boys and amounted to 12.35%, normally nourished also slightly higher with some 74.07%, overweight 6.17% and obese almost the same 7.41%. This indicates that there are differences in the nutritional status between boys and girls, which will be further, more precisely determined by statistical analyses.

Table 1 Nutritional status for the sample

Nutritional status	Percentile BMI	Boys (kg/m^2)	Girls (kg/m^2)
Malnourished	<5	≤13.78 (N=10 – 9.35%)	≤13.50 (N=10 -12.35%)
Normally nourished	5-85	from 13.79 to 17.20 (N=76 – 71.03%)	from 13.51 to 17.40 (N=60 – 74.07%)
Overweight	85.01-95	from 17.21 to 18.80 (N=13 – 12.15%)	from 17.41 to 19.40 (N=5 – 6.17%)
Obese	≥95.01	≥18.81 (N=8 – 7.47%)	≥19.41 (N=6 – 7.41%)

By taking into account the values of the multivariate Wilks' F-distribution and its statistical significance in table 2, it can be concluded that the subsamples of boys and girls differ from each other in terms of average values in the entire sample of tested body composition variables. If the significant differences are analysed individually, it can be concluded on the basis of the univariate F-test and its significance that these differences

Table 2 Gender differences in body composition

Variable	Gender	AM	S	pKS	f	p
Muscle mass percentage (0.1 kg)	Boys	11.51	2.09	0.09	13.23	**0.00**
	Girls	10.38	2.09	0.06		
Body fat percentage (0.1 kg)	Boys	5.43	3.55	**0.00**	3.37	0.07
	Girls	6.47	4.17	**0.00**		
Body water percentage (0.1 kg)	Boys	15.95	2.69	**0.01**	4.08	**0.05**
	Girls	15.12	2.60	0.20		
F=10.02; p=**0.00**						

Legend: AM-Arithmetic Mean; S-Standard Deviation; pKS-The Kolmogorov-Smirnov Test Level of Statistical Significance; f-Univariate F-Test; p-Univariate F-Test Level of Statistical Significance; F-Multivariate Wilks' F-Test; P-Statistical Significance of the Multivariate Wilks' F-Test.

were observed in favour of boys in the variables *Muscle mass percentage*, and in the variable *Body water percentage*. By analysing the variable *Body fat percentage*, it can be said that girls have slightly higher values, but they were not significant.

By taking into consideration the significance of the Kolmogorov-Smirnov coefficient, it is possible to determine the deviation in the normal distribution of the following variables: *Body fat percentage* for both genders, and *Body Water Percentage* variable among the boys. The identified deviation of the distribution was expected considering age and body fat distribution, which differs by gender.

Table 3 Group differences in body composition

Variable	Gender	f	p	PT	P
Muscle mass percentage	Boys	0.11	0.95		
	Girls	0.55	0.65	0.66	0.75
Body fat percentage	Boys	1.18	0.32		
	Girls	**11.68**	**0.00**		
Body Water Percentage	Boys	0.22	0.88	**4.56**	**0.00**
	Girls	0.37	0.77		

Legend: f-Univariate f Test; p-Univariate F-Test Level of Statistical Significance; PT-Multivariate Pillai's Trace Test; P-Statistical Significance of the Multivariate Pillai's Trace Test.

From table 3, taking into account the values of the multivariate Pillai's Trace test, it can be concluded that there is no significant difference in levels of nutrition among the boys. There are also no significant differences within the subsample of boys. When looking at the girls' subsample, it can be concluded at the level of the multivariate Pillai's Trace test that there is a difference from the aspect of body composition. If the subsample is observed individually through variables, it can be noticed from the univariate F-test and its significance that the groups differ significantly in the variable *Body fat percentage*.

Table 4 Group differences in body composition for the girls' subsample

Variable	(I) Groups based on nutritional status	(J) Groups based on nutritional status	AM (I-J)	pBonf
Muscle mass percentage	Malnourished	Normally nourished	-0.63	1.000
		Overweight	0.31	1.000
		Obese	-0.76	1.000
	Normally nourished	Overweight	0.94	1.000
		Obese	-0.12	1.000
	Overweight	Obese	-1.07	1.000
Body fat percentage	Malnourished	Normally nourished	-0.51	1.000
		Overweight	-6.79	**0.00**
		Obese	-7.58	**0.00**
	Normally nourished	Overweight	-6.27	**0.00**
		Obese	-7.07	**0.00**
	Overweight	Obese	-0.79	1.000
Body Water Percentage	Malnourished	Normally nourished	-0.71	1.000
		Overweight	0.04	1.000
		Obese	-1.07	1.000
	Normally nourished	Overweight	0.75	1.000
		Obese	-0.36	1.000
	Overweight	Obese	-1.11	1.000

Legend: Group (I)-Groups Based on BMI; Group (J)-Groups Based on BMI; Differences in AM (I-J)-Differences in Arithmetic Mean Values; pBonf-Statistical Significance of the Bonferroni's Test at the Level of $p<0.0125$.

Furthermore, to find out where the groups differ in the above-mentioned variable, a series of Bonferroni Post-Hoc tests for the girls' subsample were performed.

Based on the results shown in table 4, the following difference was concluded between the pairs of groups: malnourished and high-risk overweight in favour of higher average values for high-risk overweight, and pairs of malnourished and obese groups in favour of higher average values for the obese group. Significant differences were also observed between the pairs of groups normally nourished and high-risk overweight, and the groups normally fed and obese in favour of higher average values for obese and high-risk obese. No significant differences are observed between the following pairs of groups: malnourished and normally nourished, nor between the groups obese and high-risk overweight when it comes to the subsample of girls.

DISCUSSION

Based on the research aim, this study first analysed the nutritional status of preschool children, followed by gender differences in body composition when their nutritional status was disregarded, and finally group differences within subsamples caused by the nutritional status for both genders. The total number of malnourished children is 10.64%, normally nourished 72.34%, high - risk overweight 9.57% and obese 7.44%. This fact indicates a relative distribution when it comes to this phenomenon, because the percentile values of normally nourished children in the total sample are at a satisfactory level. This can be compared first with the percentage of malnourished children, which is not so high due to the fact that one group of children in the sample is probably with higher average values of adipose tissue, and higher longitudinal skeletal dimensionality that will take dominance in this period of growth and development in order to produce an intense growth phase. Moreover, the data could not be fully associated with poor nutrition in the previous period of life, but this fact may be somewhat related to some seasonal variations and changes in food availability. Namely, today's children and their nutrition in this part of Europe do not deviate from the findings obtained in other developed countries, whereby at this age the developmental characteristics of children and very uneven periods of growth and development must be taken into consideration. The results fully correspond to the study that was done in Serbia in the Vojvodina region, which analysed the 10-year old age group and indicated a trend of increased body height and decreased body mass and BMI parameters (Pavlica, Rakić, & Sironjic, 2017), which may on the one hand be a consequence of migration in this region, but also of diet, lifestyle and certainly the amount of movement. It is well-known that this part of Serbia has always been in the lead in higher average BMI values for both genders (Radić, 2016), and therefore the population was classified as endomorphs from the aspect of the morphological type, which cannot be stated with certainty anymore, as new studies are required. On the other hand, around 17% of the total sample falls into two categories: high-risk overweight and obese. These findings can be considered a serious threat, because it should be borne in mind that the increase in childhood obesity worldwide and in Serbia is on the rise (Padez, Mourao, Moreira, & Rosado, 2005). Namely, a report (NCD Risk Factor Collaboration, 2016) indicates that 11 million young people aged 5 to 19 were obese, and in 2016, as many as 124 million young people were obese. Obesity is most prevalent on the islands of Polynesia, in the Pacific Ocean, where more than 30% of young people are obese. More than 20% of the children in the United States, the Middle East and

some countries in North Africa are obese. The same study conducted a year later showed that every third child in Serbia is obese, and the report states that the obesity rate in Serbia has increased by 60% in the last 20 years (NCD Risk Factor Collaboration, 2017). Hence, it is no wonder that physical inactivity was declared a risk factor by the World Health Organization (2000), in addition to hypertension and obesity (Pelemiš et al., 2015). After dividing the sample by gender, a somewhat clearer picture was obtained, which indicated that there were more malnourished girls compared to the subsample of males, normally nourished also slightly higher. There were fifty percent less high-risk overweight participants and the percentage of obese participants was almost the same. Such findings may indicate possible differences in nutritional status, or even better, a non-equivalent number classified by the degree of nutritional status, which is indicated by the percentage of high-risk overweight boys that is twice as high. The increased number of female children that are malnourished and a smaller number of high-risk overweight participants indicates that girls probably have lower average muscle mass percentage and uneven levels of adipose tissue. These differences may also indicate exogenous factors, i.e., physical activity of children within organizations (preschools, sports clubs), and endogenous factors, such as higher hormonal activity.

Furthermore, after analysing the gender differences of preschool children in terms of body composition when their values of nutritional status are disregarded, some significant differences can be noticed within the subsamples. It should be noted that it is very important, in an effort to explain the body constitution of children, the focus should be on age-related instability, as well as large differences in the process of child maturation (Longkumer, 2014). The life habits of preschool children can determine the quality of their lives at this age, which will be reflected in the further overall personality development. This relationship can also be a consequence of various socio-economic factors (Pelemiš, Branković, & Banović, 2016). The increase in muscle mass in boys compared to girls may be associated with the behavioural component. This is due to the fact that the girls engage in less physical activity, that is, they engage in those types of physical activities that do not require very dynamic movements. Preschool boys engage in more physical activity, spend more energy and have less subcutaneous adipose tissue, i.e., more muscle tissue (Bailey, 2006), which is confirmed by this research. The resulting gender differences may also be influenced by factors that were not controlled, such as hereditary factors, diet, socioeconomic status, etc. Even some much earlier studies have shown that boys and girls differ in body height when they are three and a half, five and six and a half years old, where boys are slightly taller and with a higher muscle mass percentage (Bala, Jakšić & Popović, 2009). Similar findings were presented by a group of authors (Božić-Krstić, Rakić, & Pavlica, 2003; Veselinović, Milenković, & Jorgić, 2009) who state that preschool boys, in addition to being taller, also have higher upper arm and forearm measurements, and body weight, which in some cases is reflected as a higher body volume (Pelemiš, Macura, & Branković, 2017). Girls had a higher total body fat percentage during this period of development, although there was no significant difference between the genders (5.43 kg boys compared to 6.47 kg girls). Body fat percentage in girls increases during adolescence, when it doubles compared to boys, and boys gain much more muscle tissue. At that moment girls are in the lead in regard to the increase of fat-free body mass (Malina, Bouchard, & Bar-Or, 2004). Differences in body weight between boys and girls are also obvious, although they are not significant, as confirmed by the much earlier research results of Boot, Bouquet, Krenning, & de Muinck Keizer-Schram (1998).

Therefore, there are no significant changes in the subsamples when it comes to growth and development. It can be stated that growth and development occur at an even pace for

both boys and girls in this period, and that girls are slightly lighter, but with higher average values of total body fat percentage, which indicates instability in terms of adipose tissue. Upon further analysis of the research results, the subsample of girls differs in body composition at different levels of nutrition. Namely, girls who are classified as high-risk overweight and obese based on their nutritional status had more body fat than malnourished and normally nourished, which could have been expected. This phenomenon is a direct consequence of instability in the total amount of body fat percentage in girls. This can be explained by the fact that adipose tissue, which otherwise acts as a ballast when it comes to mobility, cannot always be considered useless. Namely, adipose tissue in this developmental period indicates earlier entry into the pre-pubertal phase. This is explained by the fact that the cells are filled with fat, which in this case serves as fuel so that bone growth in length would be fast and efficient. It should be noted that the structure of fat cells in children of this age consists of multinucleated smaller cells until growth and development stops, so it is natural that they break-up easier and faster, while with the cessation of growth and development this structure changes into mononuclear fat cells which are larger, and much more difficult to break down, and grow much faster (Stamatović, Šekeljić, Martinović, & Pelemiš, 2019). Therefore, adipose tissue cells are the only ones that continue to grow even after the end of human growth and development.

CONCLUSION

The value of this study is reflected in the initial evaluation of the nutritional status of preschool children, which provided a starting point for tracking their growth and development. These results obtained by the transverse cross-section of the research will change significantly in the next six months to a year. Namely, it is clear that due to the instability of the total amount of body fat percentage in girls, and reduced values of body weight and BMI compared to boys, and almost the same values of body height, girls enter the pre-pubertal phase characterized by longitudinal bone growth in length and an increase in average values of longitudinal skeletal dimensionality. That developmental period for boys can be expected in some six months to a year. The findings obtained by this research indicate that almost 17% of the total sample of high-risk overweight and obese participants can be considered alarming given the fact that this trend is on the rise world-wide and in our country. Such occurrences could be regulated by moderate motor activities, which from the aspect of biotic motor knowledge could now be upgraded to more intense forms of sports training. National strategy and activities aimed to raise awareness of the impact of physical inactivity would be crucial. The authors recommend constant monitoring of the nutritional status and physical abilities of children for six months to a year, and planning of various forms of kinesiology treatments that would be in accordance with the obtained research findings.

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TELESNA KOMPOZICIJA I STATUS UHRANJENOSTI PREDŠKOLSKE DECE

Cilj istraživanja bio je da se utvrdi postojanje polnih razlika u određenim parametrima telesne kompozicije koje su uzrokovane stanjem uhranjenosti dece predškolskog uzrasta, te grupne razlike unutar subuzoraka prouzrokavane njihovim stanjem uhranjenosti za oba pola. Ukupan uzorak sačinjavalo je 188 ispitanika sa prosečnim vrednostima telesne visine TV=124.59cm±5.76 i telesne mase TM=24.32kg±3.11, prosečnog uzrasta 6.39±0.44 godina, podeljenih po polu na dva subuzorka i to: dečaka (n=107) i devojčica (n=81) iz Beograda. Telesna kompozicija procenjena je pomoću bioelektrične impendance, uređajem InBody 230. Izračunati su glavni parametri deskriptivne statistike. Metoda MANOVA korišćena je za utvrđivanje razlika po polu u celom uzorku, dok je metoda ANOVA korišćena za utvrđivanje individualnih razlika. Izvršena je serija Post-Hoc Bonferroni testova kako bi se utvrdilo između kojih grupa postoje značajne statističke razlike. Ova studija daje ohrabrujuće rezultate tj., zadovoljavajući postotak normalno uhranjene dece oba pola, ali isto tako ukazuje na izvesni trend u rastu rizično gojazne i gojazne dece od skoro 17% ukupnog uzorka. Grupne razlike za subuzorak devojčica ukazuju na mogućnost bržeg ulaska u predpubertetsku fazu, utvrđenu na osnovu različitosti količine masnog tkiva u organizmu, ali i veće količine mišićne mase u subuzorku dečaka, te manjih prosečnih vrednosti telesne mase i indeksa telesne mase u subuzorku devojčica. Preporučuje se stalni monitoring stanja uhranjenosti i fizičkih sposobnosti dece na periode od šest meseci do godinu dana.

Ključne reči: *indeks telesne mase, kompozicija tela, polne i grupne razlike, predškolski uzrast*

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Narrative article

WHEN SPORT MEETS ART: HOCKEY NIGHT IN CANADA

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Abstract. *The paper refers to the history of Olympic art competitions which at one point were part of the Olympic Games competitions. In that vein, the author of the paper analyzes the Canadian short story Hockey Night in Canada which is inspired by sport. The story illustrates how domestic objects could be turned into objects of art and how they help Schoemperlen reflect on her characters or apply her own technique of writing.*

Key words: *Sport, Art, Sport Stories, Art, Hockey, Olympic Games*

INTRODUCTION

If we put sport and art side by side, we can see that artists and sportsmen have more in common than we can ever imagine. They both strive for excellence and success which they achieve through hard work for the pleasure of winning the game or for creating a work of art. No wonder that many writers were inspired by sport in their creative writing and many sports events and manifestation or cultural phenomena serve as the subject of their works of art. Therefore, a great number of short stories are inspired by sports events. A case in point in this paper will be a short story by the Canadian short story writer Diane Schoemperlen (1987) *Hockey Night in Canada*.

It was Pierre de Coubertin who included art within the Olympic Games. Though art exhibitions were not always competitive, the best works were awarded medals from time to time between 1912 and 1948. In the eyes of de Coubertin, art competitions were an equally important part of the Olympic Games as sports competitions. For the Olympics in Stockholm in 1912 de Coubertin succeeded in making arts part of the Games. During these games the sculpture "An American Trotter" by an American author Walter Winans was awarded a gold medal (Rios 2015). Over the next few decades, the arts competitions were underestimated and in 1948 were finally abandoned.

It is said that literature saved the Olympics. The Olympic Games were already dead when in 1833 a Greek editor, Panagiotis Soutsos, published his poem "Dialogue of the

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Dead", which featured the ghost of Plato, and which breathed life into the Games. It is also believed that Robert Browning's poem "Pheidippides", the poem about the first marathon runner, inspired the International Olympic Committee to include the marathon in the 1896 games. Apart from these examples, the intersections between sport and art are numerous.

This paper refers to the history of Olympic arts competitions which at one point were part of the Olympic Games competitions. In that vein, the author of the paper analyzes the Canadian short story Hockey Night in Canada, written by Diane Schoemperlen, which is inspired by sport as other sports stories are but, as a matter of fact, does not have much to do with hockey.

THEORETICAL CONSIDERATIONS OF THE PROBLEM

'The objects of domestic art': Hockey night in Canada

Diane Schoemperlen (1954 -) is a Canadian short story writer and novelist, one of Canada's most innovative authors today, who deals with metafictional experimentation in her prose work with an attempt to weave metafiction into factuality giving her story a social and cultural commentary and enriching her stories with a new sense of her creative imagination. In search for new techniques of realism, she often oscillates between metafiction and biographical factuality, striving to achieve some new mental literary lens through which she frames the imaginative patterns of fiction. In her stories she shows how playing with common speech can bring one back to realistic representations and meaning and how she orders and explains the emotional and mental chaos of contemporary life. However, Schoemperlen emerges not as a manipulator of language, but rather a well-focused and shrewd observer of the social and cultural reality (Andrzejczak, 2005, 24-25). Behind Schoemperlen's imaginative constructions unfolds a reality of contemporary working- and middle-class small-town Canada. Her characters are usually young or middle-aged women who talk about their lives, love affairs, children. They tell us what life is like in a world run by men, controlled by men and consumerism, permeated with paradox and terror.

Schoemperlen's technique includes a broad assortment of illustrations, ranging from diagrams to drawings or collages created by the author herself. They form an important part of the story. Certain illustrations of objects, or the descriptions of objects, like the collection of stamps she describes in *Hockey Night in Canada*, generate and shape the narratives rather than merely illustrate them. When watching hockey games, Ted and Rita roared, while Violet was arranging her stamp collection. Russia was Violet's favorite country for collecting stamps because their stamps looked bigger and grander and they displayed a variety of Russian culture: "The Russians had hockey players, cosmonauts, fruits and vegetables, wild animals, trucks and ballerinas, in red, blue, green, yellow, even shiny silver and gold. We had mainly the Queen in pastels" (Schoemperlen 2009, 264). Violet's preference for Russian stamps juxtaposes the two great countries of hockey players showing her disinterest in the game her husband and her friend are watching.

In her interview with Darryl Whetter, Schoemperlen explains that her "short stories are playing with form" (Whetter 1996, 131) but the most important thing in a short story or a novel is "that you must have a story to tell" (Whetter 1996, 131). As a student at the Banff Centre School of Writing in the summer of 1976, where she studied under such writers as W. O. Mitchell and Alice Munro, Schoemperlen was trained in the spirit that, as she says, "when you're telling a story to a friend or anyone, you're trying for a certain effect. […] you tend to make the story 'better' maybe than it really was. You tend to structure

things in a certain way. You tend to exaggerate, embroider on what actually happened" (Whetter 1996, 132-133). She concludes her thoughts on the art of creative fiction that "much of [her] fiction does derive its impetus from something that actually happened" (Whetter 1996, 133). Thus a well-known show Hockey Night in Canada becomes an inspiration for Schoemperlen to write her short story.

In the country where multiculturalism is synonymous with cultural varieties and ethnic differences which coexist together in the same space and where regional differences are as great as the differences between nations and their cultures, hockey becomes an easy recognizable means of connecting people. And when one may feel entirely out of place, hockey becomes a means of adapting to the land. For Jason Blake, "hockey is not universally adored in Canada, but it is universally recognized" (Blake 2010, 21). Hockey becomes the unifying spirit that brings the nation together, and during hockey nights and games it brings families together as well. The unifying hockey spirit may strengthen the family ties or may even destroy them.

Despite its title *Hockey Night in Canada*, the story has nothing to do with hockey. The story is about the tense relationship between a young woman's mother Violet, father Ted, and mother's friend Rita and it takes place while the Hockey Night in Canada show airs on TV in the background. It is about a middle-class family who spend Saturday evening together watching a hockey game between Montreal Canadiens and Chicago Blackhawks. Schoemperlen depicts a typical home atmosphere in the home of hockey fans. It opens up this way:

> "We settled ourselves in our usual places, my father and I, while the singer made his way out onto the ice and the organist cranked up for 'O Canada' and 'The Star Spangled Banner'. Saturday and we were ready for anything, my father half-sitting, half-lying on the chesterfield with his first dark rum and Pepsi, and I in the swivel chair beside the picture window with a box of barbecue chips and a glass of 7up" (Schoemperlen 2009, 262).

Violet, Ted, their daughter and their friend Rita seem to be bored with everyday life as they are "ready for anything" and, not knowing what to do exactly, spend the evening watching a game.

The opening of the story illustrates well enough Schoemperlen's technique and devotion to domestic objects of material culture and her devotion to establish control over her experience of objects and people. Her characters usually demonstrate the willingness to control or the lack of control. The very beginning of the story points to the fact that the characters are settled "in [their] usual places". The word "usual" signifies something stable, unchangeable, which refers to the lives of the characters Schoemperlen introduces. The opening of the story illustrates Schoemperlen's preoccupation with things, with houses and the objects that fill them, with the material objects of domestic space. In her writing Schoemperlen clearly demonstrates her devotion to forms, especially to the forms of domestic material culture. The focus in this excerpt is on the "chesterfield" sofa and "swivel chair". The chesterfield sofa symbolizes status and is one of the most recognizable pieces of furniture. It is luxurious and with a long tradition, classic in style, it derived from the long tradition of gentlemen's clubs and stately homes of the British Empire. The swivel chair, or more often the rocking chair, occupies the centre of almost every story written by Schoemperlen. The swivel chair points to the ambivalence, the possibility of a different point of view as it may be turned around, but, unfortunately, it comes full circle and can be returned to the starting point, leaving sometimes no hope of change.

The story opens with a boring middle-class evening where everything is not "real" in the family. The young lady Violet and Ted lead a make-believe life. They even pretend to be real hockey fans:

> "We were not violent fans, either one of us. We never hollered, leaped out of our chairs, or pounded ourselves in alternating fits of frustration and ecstasy. We did not jump up and down yelling, 'Kill him, kill him!' Instead, we were teasing fans, pretend fans almost, feigning hostility and heartbreak, smirking and groaning gruesomely by turns, exaggerating our reactions mainly for the benefit of the other and sometimes just to get a rise out of my mother, who was by this time humming with pins in her mouth, smoothing pattern pieces onto the remains of the dress, and snipping merrily away with the pinking shears, while scraps of cloth and tissue paper drifted to the floor all around her" (Schoemperlen 2009, 263).

This is typical for people and families with relationship problems which are a consequence of dissatisfaction with regular life, unfulfilled emotional needs which result in not being able to be what they really are. They never express their feeling the way they were; they never experienced the intensity of their emotions.

The problem of all the characters in the story is how to make a meaningful relationship with another human being and how to overcome the boredom of everyday life. Rita is Violet's friend whom she had met in the summer at Eaton's where Rita was working at the Cosmetics counter. At the time when the action of the story takes place, she works at Ladies Dresses, having passed briefly through Lingerie and Swimwear in between. Rita is a typical representative of middle-class people who divide their time between their work and their family. However, Rita's everyday routine is violated by the death of her son and her husband Geoffrey who killed himself. That caused a trauma for Rita and since then she has been trying to find a way how to heal it. She became a lonely person and joined Violet and her husband Ted in finding a way to heal her trauma.

One way out of the everyday boredom is maintaining a love affair. Schoemperlen often writes about the love affairs of ordinary women in her stories. As the story unfolds, we face an anticipation of the love relationship between Ted and Rita. It is not only emotional but it is also a sexual relationship which is implied in the passage when Ted's daughter finds him and Rita "alone in the house […] and they were drinking rum at the kitchen table, with the record player turned up loud in the living room. They seemed neither surprised nor sorry to see me. There was something funny about Rita's eyes when she looked up at me though, a lazy softness, a shining, which I just naturally assumed to be an effect of the rum" (Schoemperlen 2009, 274). They find comfort in each other due to their common feeling of being lonely. Ted was neglected by Violet emotionally and Rita, who lost her family, was blamed and isolated by her husband's family because her husband had hanged himself.

What the young lady, the narrator, witnessed upon getting back home, is the scene of the quarrel between Ted and Violet over Rita. Ted seemed to try to justify and defend his and Rita's behavior. But the whole argument ends with no resolution to the problem:

> "But he was defending her [Rita], and himself too, protecting her from some accusation, himself from some threat that I'd missed, something unfair.
> 'Well, I *know* that, Ted.'
> 'Don't forget it then.'
> 'That's no excuse for anything, you fool.'
> 'I didn't say it was.'
> 'Be quiet, she'll hear you,' my mother said, meaning me." (Schoemperlen 2009, 275)

Though Violet knows the truth about Ted and Rita's relationship, she will do nothing to change it. The story ends with the anticipation that nothing will change, they will go on with their make-believe lives, "living and partly living", not being able to bear to face the reality.

The unnamed teenage narrator in the story is a lonely woman, like Rita herself, and she sometimes fabricates familiarity with other people by imagining the lives they have, dwelling on the objects they possess which could be clues to their inaccessible lives. Visualizing the apartment of her parents' friend Rita, the narrator lets her imagination run wild:

> "The apartment would be quite small, yes, and half-dark all the time, with huge exotic plants dangling in all the windows, shedding a humid green light everywhere. The rooms smelled of coffee and black earth. The furniture was probably old, cleverly draped with throws in vivid geometrics. The hard-wood floors gleamed and in one room (which one?) the ceiling was painted a throbbing bloody red" (Schoemperlen 2009, 273).

The apartment's imagined, almost exotic, description is related to the teenager's mindset with the idea of a woman living alone. Though "such an arrangement was new to [her] then, it seemed to be a future possibility that became "more and more attractive" (Schoemperlen 2009, 273), the more she thought about it and the more she learnt about the trials of married life. It certainly marks the transformation of the narrator's identity, the change in her point of view.

Schoemperlen is in love with her objects which often fashion her characters. Preoccupied with the idea of control, Schoemperlen shows that the description of a room or a house offers the possibility of controlling experiences along with space. The fixed boundaries of domestic spaces make them seem controllable. However, the sense of control that one might possess or experience from domestic material culture is not enough sometimes. She is committed to exploring the same objects and spaces further, in greater material detail, and to exploring how they influence the lives of her characters. The furniture or decorative objects her characters are surrounded with offer a clearer, more positive image of themselves. Her characters take pleasure in seeing themselves reflected in their furniture, belongings, and the material things they possess.

Schoemperlen's story dramatizes the way in which social meaning is constructed by individuals' interactions with the manipulation of objects of material culture. As Matthew Johnson points out in *Housing Culture*: "we can all monitor someone's occupation, status, class, gender, even their political views, quite accurately from a few seconds perusal of their homes and the material culture they possess, the objects they choose to put within that space. Further, we all know how to manipulate such impressions, creating our own identities and affiliations through our own homes and material culture" (Johnson 1993, viii). The young narrator, when she imagines Rita's house, as well as Schoemperlen herself, are certainly aware of the power objects could convey about their makers, users, owners. They also contribute to the process of self-fashioning through material culture every day. Telling the story of the unnamed narrator's character transformation, Schoemperlen demystifies what is quite a mysterious phenomenon of growing up and imposing control of the world around us.

CONCLUSION

The text shows that a character's personality can be reflected both in the things or objects one possesses or choices that one makes. De Coubertin's choice to integrate art competitions into the Olympic Games tells a lot about his need to have arts as part of sports competitions and about the inevitable tie between the two walks of life. Schoemperlen, on the other hand, uses sport, or more precisely the game of hockey, as an inspiration for writing a short story. An everyday event, a hockey night in Canada, has been elevated to a higher artistic level by this short story writer. For Schoemperlen, the sports event becomes an impetus for the imaginative recreation into a story. Schoemperlen equalizes the common pleasure and

excitement of watching a hockey game with the reading of an inspiring short story. The simple domestic objects, illustrations, things which she manipulates in her story reflect a lot more about her characters, the culture, social interactions. This is the point where the trivial and the sublime intersect. The trivial becomes the source of the sublime, increasing the awareness that the things Schoemperlen surrounds her characters with generate effects, sometimes beyond the ones she intends to convey. She ponders on those trivial things which only ordinary bourgeois people may fuss over sometimes when they have nothing more meaningful to occupy their minds with, and draws the higher pleasure and thrill of manipulating the same objects of domestic art. She shows how household objects as material culture are shaped by the self that uses them or how they in turn shape that self, pointing to the role of domestic objects in the construction of characters. The comparison can be made between one's choice to have art competitions as part of sports competitions reflecting man's need to enjoy both the artistic and sports aspect of competitions, because the thrills and the enjoyment are equally rewarding in both walks of life.

For Schoemperlen, mundane and local activities and tasks of life are put almost on the same level for the sake of artistic pleasure. The focus on the importance of certain domestic activities or objects of domestic art grow out of a sense of powerlessness to effect change in the world outside home. The manipulation of material objects in everyday life could be related to the dynamics of power relations. There is "the dialectic of domination and resistance" that could be traceable in people's manipulations of material culture within a society. For example, Violet's resistance to watch a hockey game represents her everyday resistance to domination based on gender. She fashions herself in a new light via material culture which she engages in on a smaller scale when she takes to arranging the collection of stamps. On the other hand, de Coubertin's attempt to insert art competitions into the Olympic Games creates the impression of the domination of culture in a society.

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SUSRET UMETNOSTI I SPORTA: VEČE HOKEJA U KANADI

Rad se bavi istorijom Olimpijskih igara u periodu kada su takmičenja iz umetnosti bila prateći deo igara. U tom duhu autor rada analizira kanadsku kratku priču Veče hokeja u Kanadi, koju je napisala Dijana Šemperlen, i za koju su igre hokeja bile glavna inspiracije iako se priča ne odnosi mnogo na sam hokej. Priča govori o tome kako kućni objekti mogu postati deo umetnosti kada posluže kao objekti kroz koje se reflektuju likovi u priči ili kao posebna tehnika da se ispriča priča.

Ključne reči: *sport, umetnost, sportske priče, hokej, Olimpijske igre*

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