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Research article

MOTIVATION AND PHYSICAL SELF-CONCEPT AS INDICATORS OF STUDENTS' PHYSICAL ACTIVITY IN PHYSICAL EDUCATION CLASSES

UDC 796:159-005

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Abstract. *The main purpose of this article is to determine which motivational orientation (MO) of primary school students (n=240) and their physical self-concept (PSC) contribute to the intensity of students' physical activity and volume of physical activity in a physical education (PE) class. They were estimated using the pedometer and heart rate sensor. MO is measured using a modified Self-Regulation Questionnaire. PSC was measured using subscales of the Self-perception Profile for Children. In boys, PSC and motivation present better predictors of physical activity in PE elementary school classes (p<0.01), than in girls. Intrinsic Motivation and Athletic Competence have a high predictive function. Boys with a higher level of sport competence and intrinsic motivation are physically more active in a PE classes. PE classes could enhance MO and PSC by supporting basic different psychological aspect of children.*

Key words: *Behavior and Behavior Mechanisms, Self-Assessment, Exercise, Physical Education and Training*

INTRODUCTION

Physical activity (PA) presents the most important feature of physical education (PE) classes (Zapatero & Agustin, 2020). Effective PE teaching relies on student engagement (Wang, Tang, & Luo, 2017). Engagement in this context is primarily measured by intensity as well as volume of PA (Hussey, Bell, & Gormley, 2007). Research suggests that active students form health-enhancing habits, develop motor skills and competencies, improving

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positive experiences about exercise, build self-confidence, and interact with other students (Extremera, Gómez-López, Granero Gallegos, & Ortiz Camacho, 2015; Chen, Hammond-Bennett, & Hypnar, 2017). The long-term benefits of PA are dependent on frequency and intensity (Gao et al., 2017), which can deliberately be developed through school PE programs (Lahti, Rosengren, Nilsson, Karlsson, & Karlsson, 2018). Recommendations by Kim and Lochbaum (2017) suggest that children in a PE class should experience moderate-to-vigorous PA 50% of the lesson time, i.e., of the total duration of a PE class. Despite these recommendations, the level of students' PA in PE classes is consistently low in everyday teaching practice (Kremer, Reichert, & Hallal, 2012). For example, a study that utilized direct observation of PE classes in more than 1000 schools, found that students' PA in PE lesson time averaged 37% (Thomas, James, & Philip, 1992). In some classes the total duration of PA was as low as 8.6% of the total duration of a PE class, which is significantly less than the 50% recommended by educational and professional sport institution (Ridgers, Stratton, & Fairclough, 2006; Wadsworth, Rudisill, Hastie, Irwin, & Rodriguez-Hernandez, 2017).

Numerous factors have a correlation with PA levels of students in free time and in PE classes (Crocker, Eklund, & Kowalski, 2000; Ferrer-Caja & Weiss, 2000; Carroll & Loumidis, 2001; Harrison & Narayan, 2003; Pavlović, Marinković, Đorđić, & Pelemiš, 2017). Personal factors like physical self-concept and motivation have been indicated as factors that have been a manifestation of PA in PE classes in a school environment. The physical self-concept, especially a positive one, can determine the activity level but also the potential for positive development of motor skills and acquisition in PE classes (Guérin, Marsh, & Famose, 2004; Klomsten, Skaalvik, & Espnes, 2004; Marsh & Craven, 2006). Self-evaluation of physical competence in obese and less agile children also can be compromised in PE classes (Morgan, Okely, Cliff, Jones, & Baur, 2008; Morrison, Cairney, Eisenmann, Pfeiffer, & Gould, 2018). For this reason, these students prefer "less active" roles in a class, for example the goalkeeper position in football or handball. Perceived competence is key to students' engagement in PE, peculiarly for students who have less experience in sport activities (Leisterer & Jekauc, 2019). Students, who have previous positive experiences with feelings of physically competence, are inclined to consider PE more engaging and fun, and also want to involve themselves in active roles during the PE class to develop their sports skills i.e., they possess self-determined motivation-SDM (Viira & Koka, 2012; Harvey, Gil-Arias, Smith, & Smith 2017). Teachers and PE teachers should strive to increase motor skills and also the physical self-concept during lessons (Marsh & Craven, 2006). PE classes that purely aim to develop motor skills, without having an impact on student confidence, will have limited long-term benefits. Regarding the reciprocal effects model, physical self-concept (PSC) is a motivator for, and an effect of physical exercise and the student's sense of achievement (Marsh & Craven, 2006; Lazarević, Radisavljević, & Milanović, 2008).

Motivation for participation in PE classes represents an important element for the quality realization of teaching and the curriculum. For students, PE is their favourite class in school, but for some other students PE classes present a cause of stress and an important factor for non-attendance (Roberts & Treasure, 2012). Sources of motivation vary and include teachers (Reeve, Jang, Carrell, Jeon, & Barch, 2004; Ntoumanis, 2005) and peers (Hohepa, Scragg, Schofield, Kolt, & Schaaf, 2007; Slingerland, Haerens, Cardon, & Borghouts, 2013). An important premise of the Self-determination theory refers to differentiated approach to motivation. Namely, individuals differ in the level of motivation, orientation of that motivation and type of motivation (Ryan & Deci, 2000). Self-determination theory (SDT) categorizes different motivation types according to level of autonomy, whereby individuals with who are most autonomous have the most positive outcomes. SDT is also a theory based on elements of human wellness and self-development (Ryan & Deci, 2008).

Figure 1 provides a simplified visual representation of a model suggested by Ryan and Deci (2008), with motivation and regulatory styles. SDT introduces the notion that behaviour is potentially more likely to continue if people are self-motivated. Motivation and regulatory styles (see figure 1) are described as being on a scale with amotivation and intrinsic motivation on the endpoints and different levels of Extrinsic motivation (External, Interjective, Identified, Integrated), Amotivation, and Intrinsic motivation.

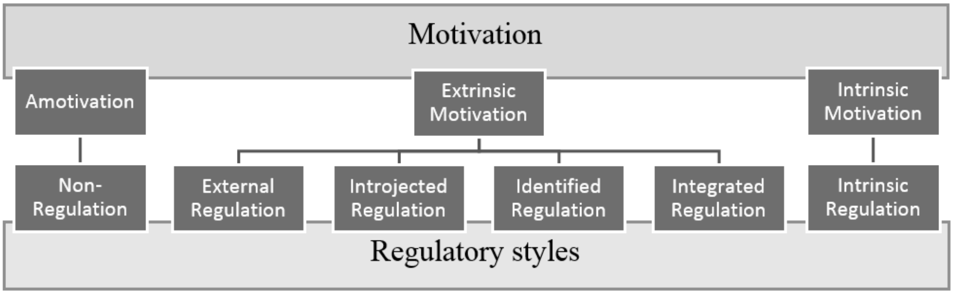

Fig. 1 Simplified structural of Self-Determination concept with motivation and regulatory styles

Individuals intrinsically motivated engage in a particular activity with elements of pleasure, challenge or satisfaction immanent in the activity itself. Intrinsic motivation is in essence a self-determined activity, as participation is voluntary, internally initiated and regulated (also known as "internal locus of causality"), supported by a pleasant experience of fun and entertainment (Ryan & Deci, 2002). As the individual gets more internally motivated, her/his behaviour gets self-determined to a larger extent, which is a basis of psychological wellness and health. Furthermore, young students' interest in participation in PE classes decreases over time, which poses a challenge to PE teaching (Sliwa et al., 2017). For example, there is a notable decline in attendance in PE classes during adolescence, especially among female students (National Center for Health Statistics, US, 2001). Also, some students have been encouraged by PE classes, although others have stopped attending them (Brooks & Magnusson, 2007). Negative experiences, such as boredom, feeling incompetent and negative peer evaluation are the main reasons for reduced activity in PE classes.

The main purpose of this article is to determine which motivational orientation (MO) of primary school students and PSC contributes to the intensity of students' physical activity and volume of physical activity in a PE class.

METHODS

Participants

The study was conducted on 240 third and fourth grade students (age 10±1.5 years; male, N=130, female, N=110). Participants usually attended PE classes three times a week at school. The classes were delivered in line with the National PE curriculum created by the Ministry of Education, Science and Technological Development of the Republic of Serbia for the 2017/18 school year. Parents and the school authorities were familiar with the aim of research and gave their written consent in compliance with the WMA Declaration of Helsinki.

The study was conducted during the spring of 2018. All of the respondents regularly attended school and PE classes. During the PE classes, the station work method was used, with six groups of students and six stations, carrying out various motor tasks according to the plan, program and curriculum. After class, students completed questionnaires in the classrooms.

Instruments

Physical self-concept was measured using the corresponding subscales of the *Self-Perception Profile for Children-SPPC* (Harter, 1982). The SPPC has proven metric properties and is widely used in similar research (Crocker et al., 2000; Jambunathan & Counselman, 2004; Mantzicopoulos, 2006; Murcia, González-Cutre, & Garzón, 2009; Kolovelonis, Mousouraki, Goudas, & Michalopoulou, 2013), and therefore considered as an applicable measure for this study. The SPPC assesses the domain (specific) perception (self) in children; and global self-worth (six subscales in total). We used the Athletic Competence subscale and Physical Appearance subscale, each of them containing six items. Athletic competence items refer to a child's competence to do well at sports, while Physical Appearance items deal with a child's perception about his/her appearance. The items are presented in the structured alternative format, i.e., as two-part sentences, with one part referring to competent behaviour of students, and the other aspects referring to incompetent behaviour (e.g., "*Some kids do very well at all kinds of sports but other kids don't feel that they are very good when it comes to sports*"). The child first chooses which part describes him/her better, and then decides if that applies to him fully or just to some extent. In this way, each item is scored on a four-point scale (from 1 to 4, where 1 indicates the lowest self-perceived competence, and 4 indicates the highest level of competence). The mean value was calculated for the subscale.

Motivational orientations were measured by the modified Self-Regulation Questionnaire (Ryan & Connell, 1989), and used for this study in = PE classes in the form presented by Goudas and associates (Goudas, Biddle, & Fox, 1994). The questionnaire has been widely used among the school-age population and can be regarded as a relevant questionnaire for this research (Fernandes & Vasconcelos-Raposo, 2005; Barkoukis, Ntoumanis, & Nikitaras, 2007; Murcia et al., 2009). It has five measuring scales for different aspects of motivation in Theory of Self-Determination (Deci & Ryan, 1985) presented as: intrinsic motivation, external, introjected and identified regulation, and amotivation. Items belonging to different subscales alternate across the questionnaire and answers are given on a 5-point scale (ranging from 1 as strongly disagreement to 5 strongly agreement). A score on each subscale is calculated by averaging responses to the items that form that subscale.

Students' *PA* was evaluated with the Coach Gear pedometer (*Coach Gear*) as well as Hear rate monitor (*Suunto Memory Belt*). Previous research determined the intensity zones (Falgairette, Gavarry, Bernard, & Hebbelinck, 1996; Pate, Baranowski, Dowda, & Trost, 1996).

As a representative intensity indicator of the students' activity during a PE class, the total time spent by the student in the zone of intense, i.e., vigorous physical activity (VPA) was used for further analyses.

Statistical analysis

For statistical analysis the Statistical Package for Social Studies SPSS (v21.0., SPSS Inc., Chicago, IL) was used. Prior to the multiple regression analyses, normality of the distribution of variables was examined by the Kolmogorov-Smirnov (KS) test. Separate multiple regression analyses were applied to resolve the relation between predictor variables (physical self-concept and motivational orientations) and two criterion variables (volume and intensity of PA during PE class). Both regressions were applied for the subsamples of different genders with the significance level set to $p \leq 0.01$.

RESULTS

This study examines the hypothesis that self-concept and motivation contribute as prediction factors to the students' volume as well as intensity of PA in a PE class. The hypothesis was upheld. The descriptive statistics results are summarized separately for the subsamples in Table 1. Based on the coefficients of variation, both subsamples are homogenous when it comes to intrinsic motivation (CV% 5.38-6.52%). The greatest individual deviations are found in amotivation in girls, and external regulation in boys.

Table 1 Result of descriptive parameters and normality of distribution for all variables in terms of gender

	Group	*AS*	*S*	*Min*	*Max*	*%CV*	*K-S*
Sport competence	Boys	2.87	.59	1.50	4	20.48	.09
	Girls	2.80	.58	1.33	4	20.64	.09
Physical appearance	Boys	3.46	.59	1.83	4	16.96	.09
	Girls	3.42	.58	1.16	4	17.04	.09
Amotivation	Boys	3.03	.69	11	3	14.36	.08
	Girls	3.59	1.67	12	3	28.61	.03
External regulation	Boys	3.21	2.95	18	6	22.15	.06
	Girls	3.47	3.11	17	6	21.49	.08
Introjected regulation	Boys	4. 01	4.59	8	20	10.54	.09
	Girls	3.81	4.28	8	20	10.11	1.00
Identified regulation	Boys	3. 52	1.59	7	20	9.97	.15
	Girls	3.52	1.71	8	20	7.79	.19
Intrinsic motivation	Boys	4.25	.45	7	15	6.52	.22
	Girls	4.01	.69	6	15	5.38	.25
Physical activity volume	Boys	2321.10	436.29	609	3346	18.79	.09
(number of steps)*	Girls	2224.15	345.43	1352	3008	15.53	.08
VPA (min)*	Boys	22.05	4.67	8.11	34.51	21.17	.08

Legend: AS-Arithmetic Mean; S-Standard Deviation; Min-Minimum Value; Max-Maximum Value; %CV-Coefficient of Variation; K-S-Kolmogorov-Smirnov Test; VPA-Vigorous Intensity Physical Activity.

Table 2 summarizes the results of the regression analyses and different power of prediction power of models. Physical Self Concept (PSC) and motivational orientations (MT); volume as well as intensity of participants' PA in PE classes were tested. Boys' physical self-concept and motivation had better predictor values of PA in a PE class, than the girls'.

Table 2 Regression analysis of predictors of students' PA during PE classes

	PA Volume		PA Intensity	
	Boys R^2	Girls R^2	Boys R^2	Girls R^2
Physical Self-Concept	9.4% (8.0%)	1.4% (1.2%)	9.7% (8.2%)	2.1% (2%)
Sport competence (β)	.25*	.09	.26*	.11
Physical appearance (β)	.16	.07	.20	.14
Motivation	6% (5.5%)	2% (1.9%)	6.5% (6.9%)	3.9% (3.8%)
Amotivation (β)	.14	.15	.13	.15
External regulation (β)	.22	.22	.25	.18
Introjected regulation (β)	.19	.08	.08	.17
Identified regulation (β)	.09	.17	.10	.21
Intrinsic motivation (β)	.29*	.19	.28	.22

Legend: β-Value of the Standardized β (Beta) Coefficient, and Corrected β (Beta) Coefficient;
*-Relations with Statistical Significance.

As shown in Table 2, the predictor system of the physical self-concept in boys explains 9.4% (PA volume in class) and 9.7% (PA intensity). The presented systems have a most powerful predictive values compared to motivation that explains 6% of the PA volume variance and 6.5% of the PA intensity of boys in a PE class. The most significant PA predictors in boys are sport competence and intrinsic motivation. Boys with a higher level of sport competence and intrinsic motivation are physically more active in a PE class. Unlike boys, physical self-concept and motivation in girls are not significant predictors of PA in a PE class.

DISCUSSION

This study analysed the predictive power of students' physical self-concept and motivational orientations in explaining PA volume and intensity in PE classes. PA was assessed by the number of steps made (volume) and heart rate (intensity). Previous studies of PA and PE have consistently indicated a correlation between types of SDM (intrinsic motivation, identified regulation) and positive consequences: greater activity in the structured and free-will (unsupervised) part of PE classes (Lonsdale, Sabiston, Raedeke, Ha, & Sum, 2009), commitment (Ntoumanis, 2001), positive emotions (Standage, Duda, & Ntoumanis, 2005), interest (Goudas et al., 1994), perseverance and concentration (Ntoumanis, 2005), self-esteem (Standage & Gillison, 2007), preferences to do challenging tasks (Mouratidis, Vansteenkiste, Lens, & Sideridis, 2008; Standage et al., 2005), a healthy lifestyle (Standage & Gillison, 2007), and an increase in PA during leisure period (Hagger & Orbell, 2003; Standage et al., 2005).

Children who identify themselves as highly competent in sports are less inclined to be externally motivated or amotivated in a PE class (Ntoumanis, 2001). Those who perceive that they lack physical competence usually consider that PE is meaningless (amotivation), and they only participate in a PE class because it is mandatory or because of fear of punishment (external regulation). Intrinsic motivation in PE classes and positive experiences of students are predictors for choosing the students' leisure-time PA (Ntoumanis, 2005). On the other hand, controlling motivation (external and introductory regulation) and amotivation are in correlation with negative outcomes, such as boredom, dissatisfaction, lack of commitment, and lack of motive to be physical active in a situation like leisure time (Ntoumanis, 2001; Standage & Gillison, 2007; Mouratidis et al., 2008).

However, our results show that physical self-concept and motivational orientations provide great insight into students' PA in a PE class only in boys. This finding suggest that girls' PA might be influenced by some factors which were not monitored in this research (attitudes about physical exercise, economic and social status, etc.). In the *PSC* predictor system, self-perception of athletic proficiency was identified as a significant contributor for volume and intensity of PA in boys during a PE class. Boys with more favourable perceptions of their athletic competence made more steps and spent more time in vigorous PA during a PE class. The *Physical appearance* variable, was not a great and significant predictor of the criterion variables. However, this might be related to the age of the respondents who may not have a sufficiently established criteria for self-assessment. Also, self-evaluation of sport competence can have a long-term (cumulative or delayed) effect on the level of PA among children and youth populations (Jaakkola, Yli-Piipari, Anthony, & Jarmo, 2015).

Similar to the predictor system of physical self-concept, motivational variables explain a small part of the variance of the criterion variables (around 6%) and this is, again, the case only in boys. Within this predictor system, the most significant single predictor is students' intrinsic motivation. Boys who are more internally motivated are more active in a PE class. In general, boys are significantly more intrinsically motivated to participate in PE classes compared to girls, and this is a relevant fact for PE teachers. Motivation largely contributes to the achievement of students in the classroom, which includes PE lessons as well (Jackson-Kersey & Spray, 2013). In a previous study (Chen, Wang, Wang, & Zhou, 2020), intrinsic motivation presented one of motivations in the line with the level of PA of the students. Kalajas-Tilga, Koka, Hein, Tilga, and Raudsepp (2020) reported that SDM positively correlates with objectively measured MVPA during leisure-time and PE. Aelterman and associates (2012) and Claver, Martínez-Aranda, Conejero, & Gil-Arias (2020) suggested that autonomous motivation is positively correlated with students' MVPA in PE. In order to stimulate intrinsic motivation in students, which means participating in activity for its own sake, it is necessary that PE classes be adjusted to the students' interests, planned and implemented in an innovative way, dynamic, diverse, and adapted to the students' abilities.

The results that indicate that physical self-concept and motivation to participate in a PE class are not significant predictors of PA in female students in a PE class, are not congruent with some previous research (Jaakkola & Digelidis, 2007; Mouratidis et al., 2008; Lonsdale et al., 2009). Although the results did not fully confirm the significance of physical self-concept and motivational orientations of female students, for them to be active in a PE class, it is important to support basic psychological needs of female students (needs for competence, autonomy, relatedness) and forms of SDM through teaching. A recent qualitative study demonstrated and confirmed that students enjoy PE classes when they feel themselves competent; when a controlled and positive, non-threatening physical and social environment is established (Lewis, 2014). Providing choice positively affects students' physical and sedentary activity during a PE class, resulting in increased student autonomy, which is in accordance with SDT (Kalajas-Tilga et al., 2020). The station format used in our study provided some control and choice to students which might mediate the correlation between motivation and PA during a PE class. When interpreting the results, one has to bear in mind developmental trajectories of controlled and autonomous motivations for PA as reported by Dishman et al. (Dishman, McIver, Dowda, Saunders, & Pate, 2015), so longitudinal data might be needed.

CONCLUSION

From the research that has been conducted, the self-determined behaviour of students in elementary school is in correlation with numerous positive consequences (psychological, behavioural, cognitive) in PE classes and can contribute to the greater engagement of students in PE classes. The findings suggest that it is necessary to provide high quality PE in schools, aimed at the formation of the students' active lifestyle, the development of motor skills and competencies, formation of a positive attitude, values and self-confidence, and acquiring knowledge necessary for participation in regular PA. Summing up the results, it can be concluded that PE classes could enhance MO and PSC by supporting basic different psychological aspects of children.

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FIZIČKI SAMOKONCEPT I MOTIVACIJA KAO POKAZATELJI FIZIČKE AKTIVNOSTI UČENIKA TOKOM ČASOVA FIZIČKOG VASPITANJA

Cilj ovog istraživanja je da se utvrdi koji tip motivacijske orijentacije učenika osnovnih škola (N=240) i fizičkog self-koncepta doprinose intezitetu i obimu fizičke aktivnosti učenika na času fizičkog vaspitanja. Intezitet i obim fizičke aktivnosti su merene pomoću pedometra i pulsmetra. Kako bi se procenio fizički samokonceptprimenjivana je skala kao merni instrument prilagođen za decu a za procenjivanje motivacionih orijentacija samih učenika na času primenjivan je prilagođeni model upitnika vazan za samoregulaciju. Rezultati su pokazali da su motivacione orijentacije i fizički self-koncept bolji prediktori fizičke aktivnosti kod dečaka (p<0.01). Unutrašnja (intrinzična) motivacija i sportska kompetencija imaju visoku prediktivnu vrednost. Dečaci sa višim nivoom sportske kompetencije i suštinske motivacije su fizički aktivniji na časovima fizičkog vaspitanja. Na časovima fizičkog vaspitanja se mogu poboljšati motivacijska orijentacija i fizički self-koncept podržavanjem osnovnih različitih psiholoških aspekata dece.

Ključne reči: *vežbanje, fizičko vaspitanje, ponašanje i mehanizmi ponašanja*

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Research article

EFFECT OF DRY-LAND DRILL ON THE PERFORMANCE OF FEMALE ATHLETES IN ARTISTIC SWIMMING

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Abstract. *It is a common practice among female athletes of artistic swimming to execute a dry-land drill of their routine just before its final execution in the water. The potential advantages of this established procedure have never been confirmed on an experimental basis. This study aimed at providing statistical evidence vindicating the dry-land drill. Forty seven Greek athletes of artistic swimming (seven of whom belong to the Greek National team) were given a routine containing standard figures, positions and movements. This routine was performed twice, with and without prior dry-land drill, executed in a random order with a lapse of one week between the two performances. The same three international judges were recruited to rate the performances in the standard three panels of execution, difficulty and artistic impression. The ratings of the performance including a dry-land drill were significantly better (paired t-test, $p<0.001$) than those without it. This improvement was consistent in all categories and levels of athletes. The enhancement in the performance brought about by the execution of a dry-land drill was more pronounced in younger athletes. The improvement in athletes' performance when they execute a dry-land drill may play an important role in the ranking of the athletes in national and international events. Dry-land drill should be recommended as a standard operating procedure in artistic swimming.*

Key words: *Artistic swimming, Dry-land drill, Performance*

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INTRODUCTION

Artistic swimming (AS) of female athletes under the auspices of The Federation Internationale de Natation (FINA) has rightly gained its entrance as an event of the Olympic Games since 1984 in Los Angeles with the solo and duet events. In 2000 at the Sydney Olympic Games, the team event replaced the solo event.

There is a specific peculiarity in AS: Regardless of the competition level and whether it is a solo, a duet or a team routine, athletes execute a dry-land drill (DLD) of their routine just before its final execution in the water. In the dry-land drill athletes simulate to the music all in-water movements on land (Mountjoy, 1999). According to the researcher, AS is a complex, highly developed, physically intensive sport that demands strength, power, endurance, flexibility, artistic expression, and performance skill. In order to synchronize to each other and the music in the routine events, AS athletes execute a dry-land drill accompanied by their music reverberating all the movements' details.

In previous research Orlick and Partington (1986) recorded the story of elite athletes of Canada participating in different sports (swimming, artistic swimming, diving, rowing, canoe, rhythmic gymnastics, shooting, alpine skiing, wrestling, basketball and figure skating), who achieved great success in world class level with the combination of mental training and tough physical training. Specifically, in AS, Kryczka and Hambrook participated in the duet event of Olympic Games of 1984 and won the silver medal. Kryczka revealed that their preparation included practice, mental training of figures and routine and dry-land drill accompanied by their music half an hour before its final execution in the water. Supplementing mental training, dry-land drill involves the actual execution of the routine outside the water.

There is enough evidence that combination of mental and physical training improves kinetic performance and yields better results (Feltz & Landers, 1983; Grouios, 1992; Hinshaw, 1991). Cox (2012) noted that athletes, in order to achieve their best performance, have to train themselves both mentally and physically. With regards to AS, Chairopoulou (2010) added that the combination of the two above training modalities outside the water combined with in-water training provide the quickest and best results. According to Martens (1987), athletes may use mental training to train quickly without physical tiredness or exposure to the risk of injuries.

The majority of research on AS revolves around injuries and common medical problems (Mountjoy, 1999; 2008; 2009), physiological requirements of the sport (Bjurström & Schoene, 1987; Naranjo, Centeno, Carranza, & Cayetano, 2006; Yamamura, Matsui, & Kitagawa, 2000; Yamamura et al., 1998; Yamamura et al., 1999), anthropometrics and its influence on athletic performance (Sajber et al., 2013), nutrition practices (Bronwen, 2011), psychological aspects and athlete satisfaction (Ntomali, Psychountaki, Kyprianou, & Chairopoulou, 2017). Additionally, synchronized swimmers have been the subject of studies based on their age or competitive category (Ebine, Feng, Homma, Saitoh, & Jones, 2000; Peric, Cavar, Zenic, & Sekulic, 2014; Sajber, Peric, Spasic, Zenic, & Sekulic, 2013) and the athletes' competition level (Ebine, Feng, Homma, Saitoh, & Jones, 2000; Homma & Homma, 2006; Rodríguez-Zamora et al., 2014; Rostkowska, Habiera, & Antosiak-Cyrak, 2005).

As mentioned before whether it is a solo, a duet or a team routine, an important component of AS training is the practice of dry-land drill before the final execution in the water. Nevertheless, up to date, there has been no report as to whether this practice is effective or not.

The purpose of the present study is, through a controlled experimental procedure, to provide statistical evidence vindicating the dry-land drill on athletes' performance when they execute the routine in the water.

METHODS

Participants

The study included 47 female athletes of AS, aged at least 13 years. Prerequisites were that: a) they were active athletes, b) they had at least two years of athletic experience, and c) they had qualified for the Greek National Championship in their category. The classification of the athletes was done on the basis of:

a) their competition category according to the rules of The Federation Internationale de Natation (FINA, 2017) into: (i) Seniors; aged at least 19 years, (ii) Juniors; aged 16-18 years, and (iii) Comen; aged 13-15 years.

b) the athletes' level into: (i) International level – members of the national team and (ii) National level – with participation only in national events.

The initial approval for the participation of the athletes was given by the head coach and the team manager of each club and by parents in cases when the athletes were under 18 years old. There followed a 15-minute briefing about the purpose of the study and what was required on the part of the athletes. After the athletes were assured that their participation was voluntary and confidential, they filled in a form concerning their athletic profile. The Ethics Committee of the university (National and Kapodistrian University of Athens, School of Physical Education & Sport Sciences), where the study was conducted, approved this study (protocol No: 1028/8/11/2017).

Measurements/Procedure

All participating athletes were given the same choreography comprising the same number of necessary elements one week prior to the start of the experiment. The routine that athletes executed was based on new FINA Artistic Swimming Rules 2017-2021 and included basic positions, transitions, figures (Rio, Porpoise Continuous Spin 720°, Aurora Twirl, Whirlwind), twists, arm movements, boosts, eggbeater, strokes and propulsion, drills required for the composition of the choreography.

The 47 athletes were randomly assigned to one of two groups (A and B). Group A performed warm-up in swimming that included swimming styles, basic positions and movements of AS. Subsequently, the athletes performed the routine in the pool that included compulsory drills of AS (2017-2021 FINA Artistic Swimming Manual for Judges, Coaches & Referees) (FINA, 2017) and were rated by three official judges of AS (Condition I: warm-up swimming and AS routine).

Group B performed warm-up in swimming that included swimming styles, basic positions and movements of AS. After this the athletes performed a dry-land drill (DLD), i.e. they performed the AS routine outside the water accompanied by music. Subsequently, the athletes performed the routine in the pool and were rated by the same three official judges of AS (Condition II: warm-up swimming, DLD and AS routine).

The AS routine was the same for all athletes. One week later, Group A performed the routine under Condition II and Group B performed the routine under Condition I.

In both conditions the rating of the athletes' performance was given by the same three official judges who are qualified to judge in National and International AS events. The competitor can obtain points from 0 – 10 using 1/10th points, as shown in Table 1, according to FINA Artistic Swimming Rules, 2017-2021.

Table 1 Grading according to the points gained in AS competitions.

Grading	Points	Grading	Points
Perfect	10	Satisfactory	5.9 – 5.0
Near perfect	9.9 – 9.5	Deficient	4.9 – 4.0
Excellent	9.4 – 9.0	Weak	3.9 – 3.0
Very good	8.9 – 8.0	Very weak	2.9 – 2.0
Good	7.9 – 7.0	Hardly recognizable	1.9 – 1.0
Competent	6.9 – 6.0	Completely failed	0

Note: AS - Artistic Swimming

Competitors were rated, according to the rules, in three panels: Execution, Difficulty and Artistic Impression. The average of the three panels gives the points for the final rating for each judge and the average of the three judges yields the final rating of the athlete's performance.

Statistical analysis

The primary outcome was the athletes' performance under two conditions (Condition I: without DLD, Condition II: with DLD). This variable will be presented as mean±SD and will be compared between the two conditions with the paired t-test, both for the total sample and for the category and level subgroups. A general linear model (GLM) was also applied including within subjects (two conditions) and between subjects (category) effects, as well as the order of execution as a random effect in order to account for any bias introduced by the effect of learning. Inter and intra-rater reliability was assessed with the intraclass correlation coefficient (ICC) also reporting its 95% confidence intervals (CI).

All analyses were performed with the IBM SPSS Statistics for Windows, version 26 (IBM Corporation, 2017) and corroborated with the R statistical package (R Core Team. R, 2016). The level of significance was set at 0.05.

Sample size calculation – Power analysis

The sample size calculation was performed on the basis of the primary hypothesis of the study that examines the difference in the performance of the athletes when the routine program is executed with and without dry-land drill (DLD). Consequently, the primary statistical test will be the paired t-test (with and without DLD) of the continuous variable of the performance as graded by three international AS judges. The expected difference of the means in the two conditions is 0.1 with a standard deviation of 0.2. If the power of the study is set to 0.9 (90%), then in order to reject the null hypothesis of no difference between the two means at the level of significance of $\alpha=0.05$, a sample size of at least 44 athletes is required. The power analysis was performed with the PS – Power and Sample Size Calculations (Dupont & Plummer, 1997) software and confirmed with the G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) program.

RESULTS

Descriptive statistics (mean ± SD) regarding the profile of participants (age, athletic experience, number of competitions) for each of the three competition categories (Seniors; Juniors; Comen) are presented in Table 2.

Table 2 Descriptive statistics (mean ± SD) for each of the three categories and for the total sample.

Parameter	Seniors	Juniors	Comen	Total
Number of athletes	9	7	31	47
Age (years)	21.7 ± 2.1	16.6 ± 0.5	13.9 ± 0.8	15.8 ± 3.3
Athletic experience (years)	11.8 ± 3.1	5.9 ± 2.3	5.3 ± 1.9	6.6 ± 3.3
Number of competitions	46.2 ± 23.4	9.6 ± 9.8	6.8 ± 3.5	14.7 ± 18.9

As Table 3 shows, both the inter and intra-rater reliability coefficients are very high. In conjunction with the fact that the ratings of the judges for the three panels in both conditions do not vary significantly (paired t-tests, p=NS), it allows to express the overall performance of each athlete in each condition by a single number that averages over the ratings of the three judges and the three panels separately for each condition.

Table 3 Inter-rater intraclass correlation coefficients (ICC) with their 95% CI for the ratings of the three judges for each panel and for the total under each condition. In italics is the intra-rater ICC between the three panels for each judge.

	Condition I (without DLD)		Condition II (with DLD)	
Panel	ICC	95% CI	ICC	95%
Execution	0.990	0.984-0.994	0.992	0.988-0.995
Difficulty	0.992	0.987=0.995	0.990	0.984-0.994
Artistic impression	0.990	0.984-0.994	0.989	0.981-0.993
Total	0.998	0.996-0.999	0.997	0.996-0.998
Intra-rater ICC				
Judge 1	*0.995*	*0.991-0.997*	*0.996*	*0.993-0.998*
Judge 2	*0.994*	*0.990-0.996*	*0.992*	*0.987-0.995*
Judge 3	*0.995*	*0.992-0.997*	*0.994*	*0.990-0.996*

Twenty-two athletes performed first the routine under condition I and the rest twenty-five athletes performed first the routine under condition II. The correlation coefficient between the rating of the athletes' performance in condition I and condition II is almost perfect (r=0.990, p<0.01), which means that the athletes managed to perform the routine in a consistent manner. However, the mean rating in condition II (with DLD) is significantly greater than in condition I (without DLD) (6.5±1.3 vs. 6.2±1.3, paired t-test, t_{46}=10.3, p<0.01). This means than in condition II the athletes performed consistently better than in condition I.

The GLM procedure showed that the order of execution of the conditions did not have a significant effect on the ratings of the athletes' performance ($F_{1,41}$=0.98, p=0.329). In contrast, the within subjects factor of the conditions had a significant effect on the ratings

($F_{1,41}$=35.4, p<0.001), as also did the between subjects factor of category ($F_{2,41}$=15.9, p<0.001). Post-hoc comparisons (Table 4) showed that the difference between the two conditions is statistically significant at the 0.05 level for senior athletes and at the 0.001 level for the junior and comen categories. Also, in both conditions the senior category scored significantly more than each of the other two categories (p<0.001).

Table 4 Mean values (±SD) of the ratings of the performance of the athletes in the routine for each category and each condition. Comparisons between conditions for each category and between categories for each condition. Asterisks denote that the senior category had significantly greater values than each of the other two categories.

Category	Condition I (without DLD)	Condition II (with DLD)	Difference	p-value
Seniors	7.9±0.9*	8.1±0.7*	0.2	0.021
Juniors	5.5±0.7	5.8±0.7	0.3	<0.001
Comen	5.9±1.0	6.2±1.1	0.3	<0.001
p(ANOVA)	<0.01	<0.01		

Note: DLD - Dry-land drill

Likewise, as Figure 1 shows, the performance of international level athletes is not comparable to the performance of national level athletes in both conditions. However, both groups evidenced a significant improvement when performing after dry-land drill. The improvement of athletes of national level was significantly greater than that of athletes of international level.

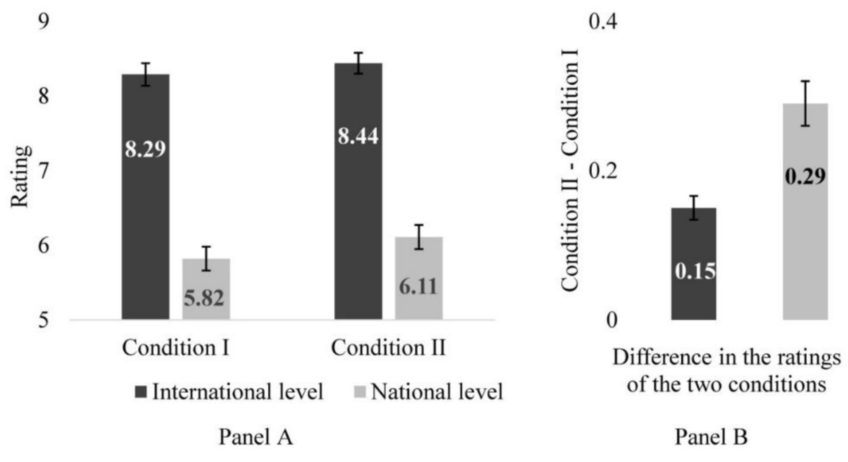

Fig. 1 Panel A: Mean ratings (with standard errors) of the athletes' performance in the two conditions depending on the athlete level. Panel B: Mean differences (with standard errors) of the ratings of the athletes' performance in the two conditions depending on the athlete level.

DISCUSSION

In AS, the dry-land drill is an important component both for trainings and competitions with athletes believing that it helps them to remember the routine they have to execute and trainers applying it in order for their athletes' performance in the water to get improved (Danardani et al., 2020). However, there is a shortage of research evidence supporting the common sense of the importance of this drill on athletic performance. Thus, this study attempted to investigate the impact of the dry-land drill on the performance of 47 AS female athletes. According to its results, the current study unequivocally corroborates, from a statistical point of view, that the established practice of performing a dry-land drill of the artistic swimming routine definitely benefits the athletes to subsequently perform the routine better in the water.

Differences in our participants' performance were not large; nevertheless, they were consistent and will definitely play an important role in the ranking of the athletes in national and international events. Our results are in alignment with Danardani et al. (2020), who also found that AS athletes improved their Free Routine Team scores after the implementation of a dry-land routine. The improvement in the performance brought about by the execution of a dry-land drill is more pronounced in younger athletes. This may be attributable to two factors: firstly, athletes of international level are more experienced and, secondly, their rating is already sufficiently high.

Artistic swimming has reached a high level of complexity, where the required figures, positions and movements have to blend together with the accompaniment of music into an artistic whole. The perfection of synchronization requires endless hours of repetition (Rodríguez-Zamora et al., 2014). To quote Mountjoy (2009): "In addition to the training required for the acquisition of sport-specific skills, artistic swimming athletes require additional training to perfect the precision of their movements. In most AS events, the athletes must synchronize their movements to each other. In the solo event of AS, athletes synchronize their movements to the rhythm, mood, and intensity of the music. At the elite level, an artistic swimmer trains in the water for 8-10 pool sessions per week including speed swimming, artistic swimming specific skills, fitness, and strength. Each training session is 2-4 hours in duration. In addition, they cross-train on land for 4-6 sessions/week, each session lasting 45-90 min in duration. The training pattern is high-volume and high-intensity, averaging approximately 40 hour per week" (p. 1,2). Moreover, Danardani et al. (2020) note that there is an escalation in AS athletes' beliefs regarding dry-land, with the younger (both in age and experience) ones recognizing dry-land as a type of exercise for remembering the routine choreography, the middle athletes understanding that it also helps them remember formation changes, and the seniors presenting a broader understanding and acknowledging the contribution of dry-land to the beauty of their routine.

This study has some limitations that should be taken into account when interpreting its results. Although female athletes aged 8-12 years participate in AS, in our sample only athletes aged 13 years and older took part; thus, we do not know how the dry-land could have affected the performance of those young swimmers. Moreover, this study focused only on a free team event. Consequently, questions regarding the importance of dry-land for the performance of athletes in solos or duets remain unanswered. However, to our knowledge this is the first study shedding light into this important issue in AS.

CONCLUSIONS

It seems that a final rehearsal through a dry-land drill evidently helps the athletes to embed the sequence in an effortless manner and provides them with confidence on the successful execution of the routine in the water. Furthermore, dry-land drills can be performed in conditions when practice in the water is not feasible because of an injury, bad weather conditions, during a journey, waiting at the changing room just before competition or to avoid training boredom. Especially with reference to addressing AS athletes' injuries and medical issues, in agreement with Mountjoy (2009), we underline the usefulness of dry-land as an effective alternative of their training in water, since, among other things, it offers a means for maintenance or/and improvement of synchronization that is an essential element of the AS routine. However, although this study provides research evidence about the importance of the dry-land drill, further research is needed so as qualitative training in AS to be informed.

In conclusion, the inferences acquired in the present study, through a controlled experimental procedure, provide verification that the established practice of execution of a dry-land drill before the final execution of the routine in the water is really beneficial.

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UTICAJ VEŠBI NA SUVOM NA PERFORMANSE SPORTISTKINJA U UMETNIČKOM PLIVANJU

Uobičajena je praksa među takmičarkama u umetničkom plivanju da izvode vežbu na suvom u svojoj rutini neposredno pre konačnog izvođenja u vodi. Potencijalne prednosti ovog utvrđenog postupka nikada nisu potvrđene na eksperimentalnoj osnovi. Ova studija je imala za cilj da pruži statističke dokaze koji potvrđuju značaj vežbi na suvom terenu. Četrdeset sedam grčkih sportista umetničkog plivanja (od kojih sedam nastupa za grčku reprezentaciju) dobilo je rutinu koja sadrži standardne figure, položaje i pokrete. Ova rutina je izvedena dva puta, sa i bez prethodne vežbe na suvom, izvedena nasumičnim redosledom sa pauzom od jedne nedelje između dva izvođenja. Tri međunarodne sudije su angažovane da ocenjuju performanse u standardna tri panela izvođenja, težine i umetničkog utiska. Ocene performansi uključujući vežbe na suvom bile su značajno bolje (upareni t-test, $p<0,001$) od onih bez njih. Ovo poboljšanje je bilo dosledno u svim kategorijama i nivoima sportista. Poboljšanje performansi koje je donelo izvođenje vežbe na suvom bilo je izraženije kod mlađih sportista. Poboljšanje performansi sportista kada izvode vežbu na suvom može igrati važnu ulogu u rangiranju sportista na nacionalnim i međunarodnim takmičenjima. Vežbe na suvom treba preporučiti kao standardni operativni postupak u umetničkom plivanju.

Ključne reči: *Umetničko plivanje, vežbe na suvom, performansa*

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Research article

THE IMPACT OF SMALL-SIDED GAMES ON COGNITIVE FATIGUE AND DECISION-MAKING ABILITY OF ELITE YOUTH SOCCER PLAYERS

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796.332-053.6

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Abstract. *Fatigue is highly correlated to performance decline. Extensive periods of cognitive and physical demands induce cognitive and physiological fatigue respectively. The purpose of the present study was to investigate the impact of the number of small-sided games (SSG) on physical loading, cognitive fatigue, and decision-making ability on the ball action of youth elite soccer players. Ten U20 players were enrolled in the study and performed six 4vs4 plus 2 GK SSGs. Physiological loading was measured from blood lactate and heart rate, for cognitive fatigue players provided subjective ratings (VAS), while the decision-making ability was evaluated through video recordings in 3 phases. The results showed that the SSGs induced high mean values for physiological loadings, and reported statistically significant fatigue after the 3rd game, based on the questions "Cognitive Fatigue" and "Cognitive Effort". Regarding the decision-making ability, players demonstrated 59.8% positive decisions in Phase A of the actions, 86.5% in Phase B, and 55.1% in Phase C with no statistical significance between games. The comparison between games 1-3 and 4-6 indicated significantly greater motor outcome effectiveness for the first group of games (63.5%). The results indicated that the number of intense SSGs in training should be selected wisely, in order to contribute to improving the quality and the effectiveness of the decision-making ability of the soccer players under the pressure of time, space, and opponents in the match.*

Key words: *Football, Fatigue, Information-processing, Decision-making*

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INTRODUCTION

Fatigue constitutes a major detriment for sports performance. It can be expressed as physical, cognitive, emotional, and behavioral (Boksem et al., 2008). Extensive periods of cognitive demands induce cognitive fatigue, which is accompanied by a subjective feeling of exhaustion, a sense of worsened ability, and a decreased willingness to engage in activities with demanding cognitive load (Zenon et al., 2019). Such higher-order cognitive demands, which are engaged in decision – making, should be considered the recognition of the relevant stimuli during visual discrimination search (Boksem et al, 2006), sustained attention to these cues (Boksem et al., 2005), performance adjustment (Kato et al., 2009; Lorist et al., 2005), and rapid and accurate response (Boksem et al., 2006). As a consequence, literature has investigated the neural signature of cognitive fatigue in modifications in the function of brain areas which mediate these cognitive demands (Ridderinkhof et al., 2004). Specifically, the alterations on the anterior cingulate cortex (ACC) function, which is responsible for performance monitoring, detecting erroneous responses and initiating compensating procedures (Botvinick et al., 2001), seem to be the underlying mechanism of cognitive fatigue. Nevertheless, neural function of the ACC time-on-task, so the reinstatement of its functioning is compromised after 60 minutes of a continued task. On the contrary, brain structures which are engaged in response preparation and control implementation as the primary motor cortex are more and immediately susceptible to cognitive fatigue (Lorist et al., 2005).

Specifically, soccer is comprised of significant cognitive requirements as sustained attention for the soccer-specific decision-making ability, which relies on the extended visual search behavior from a constantly dynamic environment and the information processing system of the brain (Vaeyens et al., 2007, Walsh, 2014). Consequently, the accumulation of cognitive fatigue is responsible for the deterioration of the decision-making ability of soccer players (Afonso et al., 2012).

Apart from cognitive functioning, cognitive fatigue depletes several physical and technical soccer-specific activities. Several researchers attempted to approach this issue, although with some important drawbacks; either implementing assessing protocols with no soccer-specific character (e.g., heart rate measurements during the Yo-Yo IR1 test or LSST, LSPT, Slalom Dribble Test measuring technical performance) (Smith et al., 2016a), or inducing cognitive fatigue in laboratory conditions (e.g., with Stroop task) before performing the major physical or technical task (Badin et al., 2015; Coutinho et al., 2018; Smith et al., 2016a; Smith et al., 2016b; Smith et al., 2018). This was at expense of ecological validity, as these researchers did not reproduce the soccer match conditions and the respective cognitive demands as the alterations in attention allocation, the tactical decision-making requirements, and the match dynamics. On the contrary, a common training method which attenuates these limitations are small sided games, as they instigate various physical, technical (Hill-Haas et al., 2011; Kelly & Drust, 2009), perceptual (Casamichana & Castellano al., 2010), and tactical conditions (Dellal et al., 2011a).

There are many forms of small sided games depending on the intensity and the tactical training purpose. Scrutinizing the most intensive of them, 4v4 SSGs induce a HR_{max} range between 85 – 90 % and the shortest possible decrease in lower limb power (Dellal et al, 2011a) in comparison with other highly intensive SSG types (2v2: 88 - 91% HR_{max}, 3v3: 87 - 90%HR_{max}) (Hill-Haas et al., 2010). In addition, 4v4 SSGs constitute a common conditioning training method during the peak of the microcycle (Köklü et al., 2013).

Regarding the restrictions of the SSGs, as the number of ball contacts, free play maintains the high intensity of the games and contributes to fewer technical and tactical mistakes (Dellal et al., 2011b). Regarding the duration of the bouts, 4 minutes seem to be a considerable time for the appearance of physiological adaptations, based on %HR (~89.5%) and high intensity activities of the players (Fanchini et al., 2011). Moreover, literature reports that a larger number of bouts is connected to higher physical load. Specifically, comparing 4-a-side and 6-a-side SSGs, there is no significant difference in matters of %HR values as they range between 85 and 92% in each case (Dellal et al., 2011a; Köklü et al., 2011).

The purpose of this study was to examine the effect of 4-a-side SSGs (plus two GKs) on player's cognitive fatigue and decision-making ability. In accordance with the literature, our research hypothesis was that, progressing above the four SSGs, physical load and cognitive fatigue will increase, which will lead to extensive impairment of the players' decision-making ability.

METHODS

Participants

Ten male professional soccer players participated in this study (Table 1). All players were part of the same U20 Greek Super League team, performed 5 training sessions (90 to 120 minutes) per week with an official eleven-a-side match played during the weekend on a regular soccer field (105 x 65 m). Two goalkeepers were part of the study but were excluded from the analysis, given their specific positioning. The study was conducted during the November of 2018-19 season, during the peak training session of the microcycle. All players were informed about the research procedures, requirements, benefits, and risks, and their written consent, as well as that of their coaches, was obtained before the study began. The investigation was approved by the Ethics Committee of the National and Kapodistrian University of Athens and it conformed to the recommendations of the Declaration of Helsinki.

Design

A field study was used to identify the effect of a number of 4-a-side SSGs (plus two GKs) on the players' physiological loading, cognitive fatigue, and decision-making ability. During the experimental session, the players performed the main protocol of six SSGs 4vs4 plus 2 GK of 4-min match play and with 3-min of passive recovery period between games, as presented in Figure 1. Physiological intensity measurements included heart rate and blood lactate measurement, Visual Analogue Scales (VAS) was used to evaluate cognitive fatigue, and a video-analysis observational instrument was used to evaluate the decision-making ability.

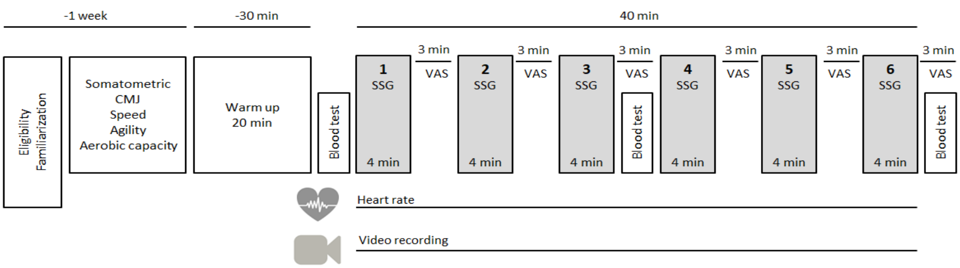

Fig. 1 A schematic layout of the experimental design.

Procedure

Preliminary measurements

One week before the experimental measurements, the players became familiar with the procedure and the instruments and were assessed for their physiological condition (Table 1). Specifically, players passed through the following tests: a somatometric examination (body height, weight, body fat %), lower limb explosiveness test with CMJ measurement (Bosco Jump Test) (Alves et al., 2010), 10m and 30m speed test (Photocells, Microgate, Italy) (Bastida Castillo et al., 2017), Little's agility (Little & Williams, 2005) test with (LTb) and without a ball (LTnb), and an aerobic capacity field test with Yo–Yo IR1 Test Performance (Bangsbo, 2016). These measurements conducted on one hand to exclude the possibility of a major involvement of any muscular or physiological fatigue on the reported cognitive fatigue, and on the other hand to confirm the participants' elite level. It is necessary to comment on the aerobic capacity indices [MPred.VO2max = 59.3±2.71 ml/kg/min, which contributed to the player's recovery from the long series of intensive SSGs performed at the 2nd phase of the treatment. Preliminary tests did not reveal any statistical differences between players, confirming a homogeneous participant status (CV<10%).

Table 1 Descriptive statistics of the preliminary measurements.

	Age (*Year*)	Height (*cm*)	Weight (*kg*)	Fat (*%*)	CMJ (*cm*)	10 m (*sec*)	30 m (*sec*)	LTb (*sec*)	LTnb (*sec*)	VO_2 max (*ml/kg/min*)
Mean	18.4	174	174	8.59	38.89	174	4.10	7.06	6.14	59.3
SD (±)	0.57	7.47	5.93	0.74	2.56	0.07	0.15	0.22	0.32	2.71
CV (%)	3.1	4.0	8.6	8.4	6.6	4.1	3.6	3.1	5.2	4.6

Experimental session

Before the experimental session, a 20-min warm-up was carried out with and without ball use (Smith et al., 2018). The ten best players were selected by the head coach according to his perception of their physical, technical and tactical skills (Sampaio et al., 2014), and then divided into two balanced teams. The 4-a-side SSG (plus goalkeepers) was performed on artificial grass as its surface 30 × 20 m (length × width) pitch using formal 11-a-side goals (Dellal et. al., 2011b). Several balls were placed around the field to allow replacement as fast as possible, while players were prohibited only from passing the ball to the goalkeeper in order to avoid game delay and intensity decline. To encourage high work-rate maintenance, coaches or other players were allowed to give verbal encouragement to all the players, but not specific feedback related to the players' performance or their technical/tactical behavior (Torrents et al., 2016). The experimental session was performed in the morning and was preceded by a day of rest. The players were asked to consume their usual meal at least 3 hours before the scheduled testing time and instructed to maintain regular sleeping patterns (at least 8 h), as well as to avoid caffeine, nicotine, alcohol, and cognitively demanding tasks before the experimental session (Badin et al., 2016).

Table 2 Decision-making observational instrument.

Phase	Category	Level	Definition
A	Starting position & ball receiving	Positive	Player receives the ball and is ready to take the next action
		Negative	Player couldn't receive ball and possession was lost
B	Decision making on ball action: Driving, Passing, Dribbling, Shooting	Positive	Decision to drive - Positive
		Negative	Decision to drive - Negative
		Positive	Decision to pass - Positive
		Negative	Decision to pass - Negative
		Positive	Decision to dribble - Positive
		Negative	Decision to dribble - Negative
		Positive	Decision to shoot - Positive
		Negative	Decision to shoot - Negative
C	Ball action execution	Positive	The execution of the ball action was positive
		Negative	The execution of the ball action was negative

Experimental measurements

Physiological loading

The measurement of blood lactate was conducted before the protocol initiation, during the 1st minute of the rest period between the 3rd and the 4th game and after the 6th game, from the pointer of the players with the Lactate Plus device (Nova Biomedica, USA). Moreover, heart rate measurement was conducted with Polar T31 cardiac tracers (Polar Electro, Finland), including a tracer zone and an electric hand watch. The tracer zone was wrapped around the thorax of the participants integrating electrodes that monitored electric load during each heart contraction, and an emitter which sent electric signal to the respective receiver (hand watch) connected with the software of the appliance. Thus, each heart rate was saved for subsequent analysis.

Cognitive fatigue

At the preliminary measurements, players had the opportunity to familiarize themselves with the questions and the marking upon the scales. In addition, researchers pinpointed the potential invalid marking in order to be avoided by the players. During the experimental session, during the 2nd and the 3rd minute of the rest period after each game, VAS were compiled from the players to evaluate cognitive fatigue, cognitive effort and motivation (Badin et al., 2016). The validity of this instrument was contrasted with EEG measurements for rating cognitive fatigue, sustaining its high practicality (Smith et al., 2019). Precisely, players responded to the following questions translated into Greek : 1) "How cognitively fatigued are you feeling right now?" 2) "How are you rating the cognitive effort you made in this SSG?", 3) "How do you classify your motivation for the next SSG?". Under each question was a 1 to 10 graded scale represented by a straight horizontal line of 100 cm, which was also indicated at the left edge as "None at all" and at the right edge as "Maximum". The players conveyed the extent of their fatigue, effort and motivation, marking a straight vertical line upon the scale between "None at all" and "Maximum". For the analysis of the questionnaire, researchers converted cm into arbitrary units (AU) and measured the distance of the player's mark from the left side of the scale.

Decision-making ability

All SSGs were recorded using a video camera (Sony UHD Video Recording FDR-AX53, Tokyo, Japan) placed on stands approximately 10 meters from the sideline and at a height of 8 meters, which allowed a view of the whole pitch without changing its position. The assessment of the decision-making ability of the players was fulfilled with the application of a video-analysis observational instrument (Table 2), considering only the player's action with the ball. Each action was divided into three phases matching the stages of the information processing model (perception, information processing, and execution of the decision) (Smith et al., 2018). In order to evaluate the stimuli perception, during the first phase (A), the starting position and ball receiving was recorded. During the second phase (B), both the selection of action (driving, passing, dribbling, shooting) and the evaluation of the decision were assessed based on the criteria provided by Gabbett et al. (2008). The final phase (C) evaluated the outcome of the execution. Two independent experienced soccer coaches (with degrees in Sports Sciences, certified with UEFA Pro license) analyzed the video footage using Lince software (Gabin, Camerino, Anguera & Castañer, 2012).

Statistical Analysis

The analysis was performed using the SPSS v26.0 statistics software (IBM, USA). The descriptive statistics were reported as mean and standard deviations for the three questions of the VAS, while normality of the distribution was assessed via the Shapiro-Wilk test ($p>.10$). The Friedman Two-Way repeated measure ANOVA was conducted to check the differences between the six SSGs based on the VAS questions. Where significant differences were found, pair-wise comparisons were performed using the post hoc Dunn-Bonferroni test to locate which pairs of games were significantly different. The Pearson (r) correlation was performed to check the relationship between the three VAS questions. A chi-square test was carried out to compare the frequency distributions between the variables (positive/negative), related to decision-making ability (Phase A, Phase B and Phase C), while a Spearman (Rho) correlation was performed to find the potential association between the dependent variables. To ensure the intra- and inter-reliability of the observational instrument, 20% of the data were reanalyzed after 2 weeks (to exclude any learning effects) by the same observer and by a different observer. The observers were trained following the protocols described by Losada & Manolov (2014). Kappa's coefficient was calculated and revealed values higher than 0.8 for all categories, thus the concordance was classified as "perfect" (Robinson & O' Donoghue, 2007).

RESULTS

Physiological loading

The physiological intensity of each game is represented by the indices of heart rate and blood lactate as mentioned before. Specifically, it is well established by the extracted data that nearly in every game, players outperformed the barrier of 89.5% of HRmax (>180.44 bpm for the examining sample). Moreover, a significant accumulation of blood lactate was reported during and after games (>4 mmol). More accurately, greater blood lactate accumulation was reported immediately after the third game (8.03 ± 1.2 mmol), while in Game 6 it approximated 6.2 ± 1.8 mmol (Figure 2).

Cognitive fatigue

Table 3 shows the descriptive statistics which represent the Mean and Std. Deviation of each of the three questions of the VAS per SSG. Friedman's Two-Way Analysis of Variance for the comparison of responses in each VAS question between the six SSGs showed a statistically significant difference for the questions “Cognitive Fatigue” ($\chi2(5)=31.805$, $p=0.000$) and “Cognitive Effort” ($\chi2(5)=26.868$, $p=0.000$). On the contrary, non-significant differences were recorded for “Motivation” ($\chi2(5)=5.590$, $p=0.348$).

Table 3 Descriptive statistics of the responses in VAS per SSG.

	Game 1 M ± SD	Game 2 M ± SD	Game 3 M ± SD	Game 4 M ± SD	Game 5 M ± SD	Game 6 M ± SD	*p*
Cognitive Fatigue	63.3± 9.20	71.5± 8.69	77.3± 6.46	82.1± 9.11	85.7±10.20	85.9± 9.91	<.001
Cognitive Effort	62.7±14.82	68.7±16.19	78.3±11.97	80.8± 9.87	82.0±14.50	82.4±14.29	<.001
Motivation	75.7± 8.74	71.8±14.94	79.1±15.30	80.6±16.61	77.8±18.66	75.4±22.48	>.10

The post-hoc analysis indicated a statistically significant difference in “Cognitive Fatigue” questions between Game1 vs Game4 ($p=0.002$), Game1 vs Game5 ($p=0.000$), Game1 vs Game6 ($p=0.000$), between Game2 vs Game4 ($p=0.023$), Game2 vs Game5 ($p=0.001$) and Game2 vs Game6 ($p=0.001$), and between Game3 vs Game5 ($p=0.013$) and Game3 vs Game6 ($p=0.013$). Moreover, significant differences were reported for the “Cognitive Effort” question between Game1 vs Game3 ($p=0.045$), Game1 vs Game4 ($p=0.008$), Game1 vs Game5 ($p=0.003$), and Game1 vs Game6 ($p=0.001$).

Moreover, Pearson’s correlation between the three VAS questions revealed significantly positive values [r(Cognitive Fatigue- Cognitive Effort)=.884, p=.004, r (Cognitive Fatigue-Motivation)=.724, p=.042 και r (Cognitive Effort - Motivation), 48=.788, p=.020].

Decision-making ability

Phase A - Starting position and ball receiving

From 396 examined ball receive actions, the players assumed a right staring position in 59.8% (237) of them, while in 40.2% (159) they made a starting position under pressure from the opponents or the hold bad position, which was preventing the forward game. Overall, players received the ball in 97.2% (385) of the cases to continue on the next action, with only a 2.8% (11) tries ending with ball loss ($\chi2(2)=87.059$, $p<0.001$, cc=.425).

Phase B - Decision-making on ball action

During the second phase of the competitive actions, as depicted on Table 4, from the 385 positive ball receive actions, the players decided to perform a passthe (44.9%), driving (36.6%), shooting (14.8%) and dribbling (3.6%). From these actions players performed a significantly higher number of positive decisions (86.5%) in comparison to negative ones (13.5%). Precisely, chi-square test reported significant differences in frequency distribution of positive and negative decisions within the four action types ($\chi2(3)=8.046$, $p<0.05$). Nevertheless, the overall comparison of positive and negative decisions independently of the action type within the six SSGs (Figure 2) showed non-significant differences ($\chi2(5)=9.262$, $p=0.099$, $\varphi=0.099$).

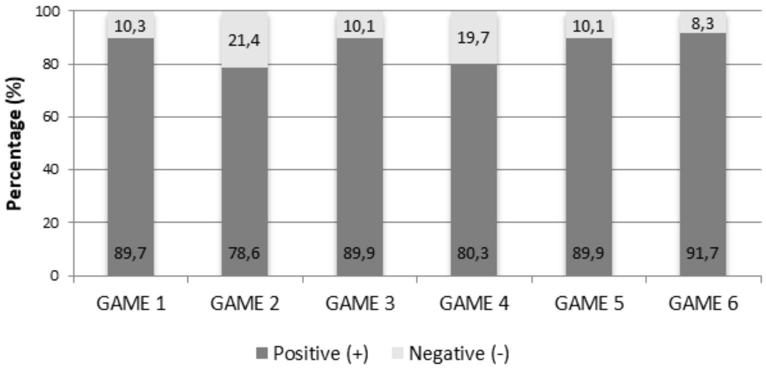

Fig. 2 Decision-making on ball action per SSG.

Phase C – Ball action execution

Although the majority of actions during the execution phase proved to have a positive note (55.1%), non-statistically significant differences were found at the frequency distribution among the four action types ($\chi^2_{(3)}=4.489$, $p=0.213$, $\varphi=0.213$). Table 4 reveals that driving and passing demonstrated positive execution (51.8% and 60.7% respectively), while dribbling and shooting more negative execution (57.1% and 50.9% respectively).

Table 4 Decision-making on ball action (B) and Execution (C) per ball action.

Ball Action	Total N (%)	Decision-making (B)		Ball action execution (C)	
		Negative	Positive	Negative	Positive
		N (%)	N (%)	N (%)	N (%)
Driving	141 (36.6)	27 (19.1)	114 (80.9)	68 (48.2)	73 (51.8)
Passing	173 (44.9)	15 (8.7)	158 (91.3)	68 (39.3)	105 (60.7)
Dribbling	14 (3.6)	1 (7.1)	13 (92.9)	8 (57.1)	6 (42.9)
Shooting	57 (14.8)	9 (15.8)	48 (84.2)	29 (50.9)	28 (49.1)
Total	385 (100.0)	52 (13.5)	333 (86.5)	173 (44.9)	212 (55.1)
		$x^2_{(3)}=8.046$, $p=0.045$*, $\varphi=0.145$		$x^2_{(3)}=4.489$, $p=0.213$, $\varphi=0.213$	

Notes: *=p<0.05. **=p<0.01. ***=p<0.001

Concerning the effect of the decision made in the second phase of the action (B) on the execution of the third one (C), statistical analysis indicated that 96.2% of the 52 negative decisions of the second phase led to negative execution (Table 5). On the contrary, 63.1% of 333 positive decisions contributed to positive execution of the players. This finding was also validated by the Spearman correlation, which presented an increased and significant correlation between the decisions of the two phases ($\rho=.407$, $p<.001$).

Table 5 Relationship between effectiveness of decision-making (B) and ball action execution (C).

Variables		Ball action execution (C)			
Decision-making (B)	N	Negative N (%)	Positive N (%)	Chi square	Phi Coefficient (Phi)
Negative decision	52	50 (96.2)	2 (3.8)	$x^2_{(1)}$=63.741	.407
Positive decision	333	123 (36.9)	210 (63.1)	p=0.000***	
Total	385	173 (44.9)	212 (55.1)		

Note: *=p<0.05. **=p<0.01. ***=p<0.001

Assessing the effectiveness of the action execution between the six SSGs, the comparison between Games 1-3 and 4-6 unveiled a significantly higher relative frequency of effectiveness for the first cluster of games (63.5%) against the second one (47.8%) ($\chi^2_{(1)}$=9.482, p<0.01, phi=.155). This particular finding is depicted in Figure 3, which highlights the effect of the number of games on execution effectiveness on ball actions, apart from cognitive and physiological fatigue.

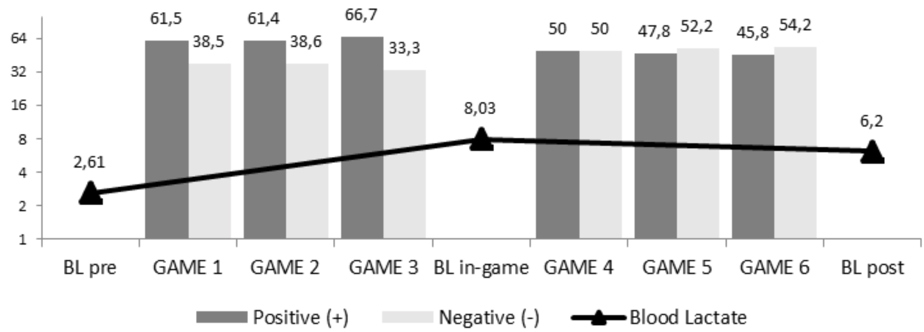

Fig. 3 Blood lactate concentration and effectiveness of ball action execution (C) per SSG.

Discussion

The purpose of the current study was to investigate the potential impact of SSGs during a training session on cognitive fatigue and the decision-making ability of the players. A number of intensive SSGs above four was associated with higher values of subjective cognitive fatigue and the impaired outcome of the decision-making process of the players, which is consistent with our research hypothesis.

In line with a recent study (Trecroci et al., 2020), we assessed decision-making ability of the players defined from the technical-tactical performance in a common realistic soccer-specific training method as SSGs. In field method, this secured the ecological validity of our study, in contrast to researches using laboratory film-based simulations (Smith et al., 2016b; Vaeyens et al., 2007). Having ensured the adequate physical intensity of the games (which emerged from the heart rate and blood lactate measurements) (Dellal et al, 2011a; Fanchini et al., 2011), significant differences were found during VAS responses of cognitive fatigue and effort concepts exept from motivation of the players. In fact, the fourth game proved to be a critical benchmark for the perceived cognitive fatigue and effort, as greater mean values in the VAS were recorded for games 5 and 6. Given the fact that SSGs can potentially induce cognitive fatigue, our results for cognitive fatigue and effort are aligned with studies, which provoke and examine cognitive fatigue with paper/computer-based Stroop tasks, video-watching or tactical sessions (Badin et al., 2016; Coutinho et al., 2018; Smith et al., 2016a; Smith et al., 2016b; Smith et al., 2018). At the same time, the experimental manipulation between these studies and ours still remains controversial, as our endeavor focused on addressing the cognitive-fatigue induced from the SSGs with no intention of seeking pre-triggered cognitive-fatigue effects on SSG performance.

In particular, the findings for motivation are in accordance with the study of Smith et al. (2016b), who reported similar values for these parameters after cognitive fatigue treatment – given the consensus that game progression caused cognitive fatigue. As the authors mentioned, their – and our – findings are in opposition with inverse relationship between cognitive fatigue and motivation, which was reported by Boksem and Tops (2008). Moreover, this result is contradictory to previous research carried out by Boksem and his colleagues (2006), which also indicates that as the subjective effort overcomes the possibility of reward at the end of the task, the motivation to sustain productivity until the end ceases to exist and the participant feeling fatigue desires to be disengaged from the task. A possible explanation for our findings could be the vigourous verbal encourgement provided by the players' coach throughout the overall treatment, which was also reported by Barte and his colleagues (2019). Another safety valve to establish our findings was the positive correlation in value augmentation between each pair of cognitive indices.

The other primary indication of our study was the effect of the SSGs on the decision-making ability of the players. The implicated extensive technical-tactical notational analysis of the recorded activities provided a cascade of sub-actions accompanied with evaluations of the respective decisions. At first, the ability of the players to scan the dynamically changing environment and attend to the most essential cues was assosiated with the motor response of their starting position and ball receive (Nedelec et al., 2012). Particularly, a significant difference was found between safe and risky or bad starting position and the quality of the ball receive. Precisely, better location in the field was associated with a promising ball receive. The stage of integration of relevant information as the opponents' and teammates' position with tactical behavior and the selection of consecutive motor execution was assesed during the second phase of the action (Smith et al., 2018). The results indicated a greater number of positive decisions, for most of the action types (e.g. passing). Progressing to the third phase of the action, a similar pattern emerged for the execution outcome.

Furthermore, the results highlighted the contribution of the second decision for execution of ball action (the third phase), as automatically planning and selecting a correct action is correlated with better execution (Diedrichsen & Kornysheva, 2015). Finally, retrospecting the impact of the number of games on the overall decision-making ability, gradual decrease was demonstrated for the phase to phase performance of activities, which looks reasonable if we reflect on the effect of physiological intensity and the highly cognitive demanding task of the games (Smith et al., 2016a). Moreover, the outbreak of the opponents' pressure could potentially limit the range of playing options

(Phillips et al., 2010). On the contrary, the number of games had no clear effect on the same action phase (A,B,C). Especially considering the first phase (A), our findings are in agreement with the study of Smith and his colleagues (2016b) who invsestigated visual search behavior of youth soccer players and found no evidence for the effect of cognitive fatigue in this competence, which is related strongly to perception (the first stage of information processing and decision-making).

Independently of the game's progression, supplementary findings concerning the correlation between decisions unveiled a positive correlation of positive decisions throughout the task. Finally, the number of games had an effect on the execution outcome, as significant differences were found between game clusters 1-3 and 4-6. This result remains in line with the present literature (Smith et al., 2018) and with the cognitive fatigue findings, highlighting similar effect of the number of games on technical and tactical performance, which reflects the decision-making ability of the players.

In general, these findings are in accordance with previous studies, which pointed out the negative effect of intensive games on the decision-making ability of the players. Previous research (mentioned before for cognitive fatigue increase) complies with this finding, on the condition that SSGs induce cognitive fatigue and therefore diminish the decision-making ability by reverting the sources of attention to irrelevant cues and impairing information processing (Linden et al., 2003). Despite this congruency, to be accurate, the purpose of these studies was to investigate the effect of pre-disposed cognitive fatigue on cognitive processes as decision-making and its observable outcome – technical/ tactical performace. As a consequence, we could not indicate a salient point of convegence between them and us. Overall, our method was the one that obtained the most robust results for the decision-making process, as the extent of our analysis demonstrated and evaluated the whole decision-making process, and not only its outcome (Badin et al., 2016; Smith et al., 2016b; Trecroci et al., 2020).

Despite the novelty of the research problem of investigating cognitive fatigue and the decision-making ability during realistic training conditions such as SSGs, the current study features some limitations. At first, in spite of its purposeful validity, VAS remains a subjective report of the athlete regarding his perception about his cognitive state. More objective techniques such as electroencephalography for recording brain waves relative to decreased function of the frontal lobe (where post-synaptic action potentials reveal the localization of decision-making ability) (Balasubramanian et al., 2011; Lorist 2005) or reaction-time behavioral tasks to validate the state of declined vigilance (Lamond et al., 2005) could be appropriate proxies, in order to eliminate the possibility of physiological fatigue interference. On the other hand, it is uncertain whether such techniques could be implicated in such a field of study.

In terms of investigating the physiological intensity and its potential engagement in decision-making, more sophisticated methods could have been recruited as GPS measurements (Fernandes-da-Silva et al., 2016). Nevertheless, such an extensive analysis about the physical characteristics of fatigue were beyond the scope of this study. In fact, heart rate and blood lactate were used to depict that the games were performed actually at the right intensity. Concerning sample size, only the most skillful players of one elite team participated in the study, something that guides future research to examine more teams in to order to increase their amount of data.

Considering all the above-mentioned topics and the methodological issues of the current study, future work should concentrate on replicating our approach in full-length match conditions, in order to record differences compared to SSGs in matters of cognitive and decision-making exhaustion (Smith et al., 2018). Moreover, our proposal for extending the diversity of the extracted data is to implement our approach among professional soccer players or players of grassroots ages and other competences. Furthermore, a longitudinal study could investigate the differences within several training sessions regarding cognitive fatigue and decision-making, in order to derive purposeful conclusions about players learning adaptation within SSGs.

CONCLUSIONS

Overall, the findings of the current study demonstrates a significant effect of the number of intensive SSGs on the cognitive fatigue and decision-making ability of elite youth players. Precisely, it could be inferred that three to four SSGs could be an effective prescription guideline for coaches, in order to deliver an exerting training protocol within the accomplishment of the technical-tactical learning profit. To our knowledge, this is the first report addressing the issue of cognitive fatigue during a realistic training condition, which is a close approximate of the match. These results did not delve deeper to seek the neurophysiological signature of cognitive fatigue and the diminished decision-making ability. Nevertheless, according to the literature, potential factors include the decreased function of the anterior cingulate cortex and execution functions, which assist decision processes (anticipation/identification of relevant cues, their interpretation and forging the appropriate response). In the direction of covering this issue, our notational analysis for the evaluation of decision-making was carried out at greater depth in comparison to previous studies.

The current study sustains a high level of practical implications, as it is supposed to modify coaches' perceptions about the critical issue of designing their training programs based on the optimal amount of load for their players. The reported data of our research indicated that elite soccer players could gain learning profits for their decision-making ability, when a definite number of intensive SSGs is performed. The major condition for coaches to reach the aforementioned is to foster the evaluation of more validate subjective ratings such as VAS, in order to monitor their players' cognitive and not just physical fatigue throughout the training process.

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UTICAJ IGRE SA MALIM BROJEM IGRAČA NA KOGNITIVNI UMORU I SPOSOBNOST ODLUČIVANJA ELITNIH MLADIH FUDBALERA

Umor je u velikoj meri povezan sa smanjenjem performansi. Dugi periodi kognitivnih i fizičkih napora izazivaju kognitivni i fiziološki zamor. Svrha ove studije bila je da se istraži uticaj broja igre sa malim brojem igrača (SSG) na fizičko opterećenje, kognitivni umor i sposobnost donošenja odluka na akciju loptom mladih elitnih fudbalera. Deset U20 igrača je upisano u studiju i izveli su šest 4 na 4 plus 2 GK SSG. Fiziološko opterećenje je mereno na osnovu laktata u krvi i pulsa, za kognitivni umor igrači su davali subjektivne ocene (VAS), dok je sposobnost donošenja odluka procenjivana kroz video snimke u 3 faze. Rezultati su pokazali da je SSG indukovao visoku srednju vrednost pri fiziološkim opterećenjima i prijavio statistički značajan umor nakon 3. igre iz pitanja „Kognitivni umor"i „Kognitivni napor". Što se tiče sposobnosti donošenja odluka, igrači su pokazali 59,8% pozitivnih odluka u fazi A akcija, 86,5% u fazi B i 55,1% u fazi C, ali nisu značajne između utakmica. Poređenje između igara 1-3 i 4-6 pokazalo je značajno veću efikasnost motoričkog ishoda za prvu grupu igara (63,5%). Rezultati su pokazali da broj intenzivnih SSG-a na treninzima treba da se bira mudro, kako bi se doprinelo poboljšanju kvaliteta i efektivnosti sposobnosti donošenja odluka fudbalera pod pritiskom vremena, prostora i protivnika na utakmici.

Ključne reči: *fudbal, umor, obrada informacija, donošenje odluka*

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Research article

THE RELATIONSHIP BETWEEN ANTHROPOMETRY AND LEG FREQUENCY MOVEMENT IN THE EGGBEATER KICK UNDER EXTERNAL LOADS IN WATER POLO

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Abstract. *We intend to investigate whether specific anthropometric characteristics and/or frequency of leg movement are related to the water-polo players' ability to resist external pressure during the eggbeater kick. Twenty-four male water-polo players participated in this study. Preliminarily, the participants' anthropometric characteristics were measured. Thereafter, a 20-sec eggbeater kick test was conducted in order to determine the minimum load the participants could resist. On the day of the experiment, each participant performed the 20-sec eggbeater kick test, starting from 10 kg and thereafter with a progressive increase of 1 kg external load until peak external load (PEL) was reached. The external load the players could effectively resist before the failed effort was considered the PEL. Significant correlations between the majority of anthropometric characteristics and PEL were observed (r=0.38 to 0.62, P<0.05). Multiple regression analyses revealed that stature and body mass explained the total variance of PEL by 67% and 58% respectively (P<0.05), while frequency of leg movements were also significant predictors explaining more than 45% of PEL variance (P<0.05). The factor analysis showed that anthropometric characteristics and leg frequency movements totally explained 80.42% of the PEL variance. However, the multiple regression analysis based on scores from the factor analysis revealed that only anthropometric characteristics were significant predictors of PEL during the eggbeater kick, explaining more than 37% of the total variance (P<0.05). The present study indicates that anthropometric characteristics are more important predictors of the performance of the eggbeater kick.*

Key words: *Performance test, water-polo players, stature, body mass.*

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INTRODUCTION

During a water-polo match-play, players perform swimming movements from the horizontal and vertical position. The eggbeater kick is a fundamental skill that is used for the execution of vertical movements and is performed to keep the athlete afloat in an upright position while performing other skills such as passing, shooting, defending, and attacking. Namely, it consists of cyclical actions with the motion of the right and left lower limbs in opposite phases (Sanders, 1999).

Water-polo is characterized by a high presence of body contact between the players (Platanou, 2004). Several match-analysis studies have shown that dynamic body contacts or even wrestling are often performed between opponent players and specifically between center forwards and center defenders (Platanou & Geladas, 2006; Smith, 1991). In particular, center forwards have to wrestle in an attempt to gain a better position executing the eggbeater kick under an opponent's external pressure, which is often performed on his/her shoulders by center defenders in an attempt to gain a better position and to steal the ball. During this game situation, an effective eggbeater kick would result in a greater height maintenance that may allow for a successful turning or shot from the center-forward. Resistance against an opponent's pressure is dependent on the forces generated upwards to raise the body reacting on the rival's pressure. The eggbeater kick consists of cyclical actions with the motion of the right and left lower limbs. In this action, the frequency of leg movement might play a crucial role in height maintenance and in resistance against external pressure.

Many studies in other team-sports have demonstrated the importance of anthropometric characteristics in performance success (Wong, Chamari, Dellal, & Wisloff, 2009; Van den Tillar, & Ettema, 2004). In aquatic sports, it has been suggested that body mass and body length might affect the total energy cost in swimming (Kjendlie, Imgjer, Stallman, & Stray-Gundersen, 2004), that some anthropometric characteristics are related to the 100 m freestyle time in swimming (Geladas, Nassis, & Pavlicevic, 2005), and that a greater body size might be advantageous in order to obtain better position in the pool and to reach and control passes in water polo (Tsekouras, et al., 2005). Furthermore, it has been observed that the greater the body length, the higher the throwing velocity of female water-polo players (Platanou & Varamenti, 2011). However, to our knowledge, no data exist on the influence that anthropometric characteristics have on an effective eggbeater-kick performed under external loads in water-polo.

Accordingly, the aim of the present study was to investigate whether specific anthropometrical characteristics and/or frequency of leg movements are related to the water-polo players' ability to resist external pressure during the eggbeater kick. We hypothesized that water-polo players' anthropometrics in conjunction with leg frequency would affect performance during the eggbeater kick under external loads.

METHODS

Participants

Twenty-four male water-polo players (age: 23.5±3.0 years, body height: 182.31±7.39 cm, body mass: 84.67±9.85 kg) volunteered to participate in this study. All the participants were elite water-polo players who participated in the First Greek National Division Championship. Written informed consent was obtained from all the players before the commencement of the study. All the procedures had the approval of the local

Ethical committee and conformed to the Declaration of Helsinki. All of the participants were tested on 2 different occasions: a preliminary exercise test and the main experimental trial: the eggbeater kick performance test.

Testing procedures

Preliminary testing

Several days before the main experiment, a preliminary exercise test was conducted in order to determine the minimum external load (kg) that the participants could resist during the eggbeater kick with hands in the water. For this purpose, loads were placed in a diving belt that was positioned on the participants' shoulders. In particular, ten participants performed a 20-sec eggbeater kick with hands in the water. The loads progressively increased per 5 kg in each attempt until the participants could not resist it. Twenty seconds is considered to be the maximal time a player is under external pressure executed by an opponent after two consecutive offences in water-polo. It was found that the minimum load that the players could resist was ~10 kg and consequently it was chosen as the baseline load for all participants.

A day prior to the main experimental test, the participants' anthropometric characteristics were measured. All of the measurements (arm length, forearm length, hand length, lower limb length, biceps girth at rest and after contraction and foot length) were performed according to the anatomical standards set by Ross & Marfell-Jones (1991). Body mass was measured without shoes on a standing scale (Bilance Salus, Italy) that was calibrated to 0.1 kg. Stature was measured without shoes on a wall-mounted stadiometer (Bilance Salus, Italy) with an accuracy of 0.001 m.

The eggbeater kick performance test

On the day of the experiment, after a 10-minute standardized warm-up (400-m freestyle swimming, 100-m breaststroke swimming), each participant was instructed to perform the eggbeater kick, starting from the baseline load of 10 kg placed on their shoulders, which lasted for 20 seconds. Thereafter, a progressive increase of 1 kg external load was performed until the participants could not resist the load as exhibited by touching the water with their mouth. The external load the players could effectively resist before the failed effort was considered as the PEL. Each attempt lasted for 20 sec, which began and terminated with a whistle blow and was interspersed with a 5-min passive rest. Additionally, during the 20-sec eggbeater kick test, the number of movements of both legs was counted. The leg movements during the eggbeater kick were monitored underwater by a video-camera (Panasonic MS5, Japan). Thereafter, slow-motion analysis was used to count the players' leg frequency.

Statistical analysis

Statistical analysis was performed with SPSS for Windows, version 16 (SPSS, Inc., Chicago IL, USA). Data are reported as means ± SD. Before using parametric statistical test procedures, the normality of the data was verified by the Kolmogorov-Smirnov test. Pearson's (for parametric variables) or Spearman's (for non-parametric variables) correlation was employed to detect significant correlations between anthropometrics and maximal external loads. A forward stepwise multiple regression and factor analysis were used to identify factors that determine the maximum external loads during the eggbeater kick. The threshold for significance on all the tests was set at $p=0.05$.

RESULTS

The participants' anthropometric characteristics, the PEL and the frequency of leg movements are presented in Table 1. An average load of 14.86±3.51 kg was identified as the PEL, while the respective number of leg frequency during the 20-sec eggbeater kick test was found to be 35.88±2.68 repetitions/20sec.

Table 1 Anthropometric characteristics, PEL and legs frequency movement during the eggbeater kick test. Values are means±SD. Δ biceps= difference in bicep girth between rest and during contraction, PEL=peak external load, reps=repetitions.

Variables	Mean Values
Body weight (kg)	84.67 ± 9.85
Stature (cm)	182.31± 7.39
Arm length (cm)	80.52 ± 5.52
Forearm length (cm)	47.20 ± 3.80
Hand length (cm)	20.07 ± 2.63
Lower limb length (cm)	93.32 ± 5.38
Knee length (cm)	49.88 ± 10.86
Foot length (cm)	10.83 ± 1.49
Bicep girth at rest (cm)	31.55 ± 3.33
Bicep girth during contraction (cm)	35.38 ± 3.44
Δ biceps (cm)	3.83 ± 1.38
PEL (kg)	14.86 ± 3.51
Legs frequency (reps/20 sec)	35.88 ± 2.68

The Kolmogorov-Smirnov test revealed that all variables were normally distributed except for knee length (p=0.02). Consequently, a non-parametric correlation (Spearman R) was used to identify correlations between knee length and other anthropometrics. Pearson's correlation showed that the majority of the anthropometric variables significantly correlated with the PEL. In particular, the variables that exhibited the most significant correlations with the maximum load that the players could resist were: stature, body weight, arm length, forearm length, bicep girth at rest and during contraction, lower limb length, and foot length (Table 2). No significant correlations were observed between hand length, knee length, and the difference (Δ) in bicep girth between rest and during contraction with PEL (p>0.05).

Two different multiple regression models were tested. The first multiple regression model with independent variables of the stature, hand length, difference between biceps at rest and during contraction, foot length, and frequency of legs, revealed that only stature and frequency of legs were significant predictors of PEL, explaining 67% and 45% of the variance of PEL (p=0.01 and p=0.03, respectively, Table 3). In the second multiple regression model, the replacement of stature with body weight demonstrated that only body weight and leg frequency movement were significant predictors of PEL, explaining 58% and 48% of the variance of PEL (p=0.00 and p=0.01, respectively, Table 3).

Table 2 Correlation coefficients between anthropometric characteristics and PEL PEL=peak external load, Δ biceps= difference in bicep girth between rest and during contraction, * statistically significant at $p<0.05$, ** statistically significant at $p<0.01$.

Anthropometric characteristics	PEL
Body weight	0.55*
Stature	0.59**
Arm length	0.62**
Forearm length	0.42*
Hand length	0.14
Lower limb length	0.42*
Knee length	0.15
Foot length	0.19
Bicep girth at rest	0.26
Bicep girth during contraction	0.38
Δ biceps	0.33

Table 3 Multiple regression results for the prediction of variance in peak external weight during the eggbeater kick from two different regression models

Dependent variable	Independent Variable	β	Beta	P	R^2	Overal P
Model 1					0.52	0.014
PEL (kg)	Stature (cm)	0.56	0.67	0.016		
	Leg frequency (reps/20sec)	0.29	0.45	0.003		
Model 2					0.48	0.026
PEL (kg)	Weight (kg)	0.19	0.58	0.005		
	Leg frequency (reps/20sec)	0.59	0.48	0.015		

The factor analysis revealed three factors that predicted 80.42% of the PEL variance. The first factor and the second factor included all anthropometric variables measured and were found to share variables with similar loadings (Table 4).

Table 4 Varimax rotated factor matrix for the three-factor solutions

	1st solution factor	2nd solution factor	3rd solution factor
Body weight	0.61	0.48	0.31
Stature	0.68	0.55	0.32
Arm length	0.82	0.48	0.11
Forearm length	0.84	0.23	0.03
Limb length	0.64	0.38	0.45
Knee length	0.06	-0.85	0.14
Foot length	0.82	0.10	0.08
Biceps at rest	0.91	-0.08	0.11
Biceps during contraction	0.90	-0.11	0.11
Legs frequency	-0.06	0.09	-0.95

The third factor included the leg frequency variable only. Based on scores of the factor analysis, a third multiple regression model was run with the PEL as the dependent variable and the scores from the factor analysis referring to the three factors as the independent variables (Table 5). It was observed that only the anthropometric characteristics were significant predictors of PEL, explaining 45% and 37% of the variance, respectively.

Table 5 Multiple regression results for the prediction of variance in peak external load during the eggbeater kick from the factor analysis scores

Dependent variable	Independent variable	β	Beta	P	R^2	Overal P
Model 3					0.38	0.019
PEL (kg)	Factor score 1	1.47	0.45	0.019		
	Factor score 2	1.22	0.37	0.048		
	Factor score 3	-0.73	-0.22	0.225		

DISCUSSION

The eggbeater kick with external pressure executed by opponents is an action that is observed frequently during a water-polo game. Leg frequency and anthropometric variables have been proposed to affect the effectiveness of the eggbeater kick. We investigated the extent to which the anthropometric variables and leg frequency movement affect the PEL during the eggbeater kick. To accomplish our goal, we simulated the external pressure that is executed by opponents during an eggbeater kick with progressively added loads which were placed on the participants' shoulders. The present results indicate that significant correlations exist between the PEL a player can resist during an eggbeater kick with the majority of the participants' anthropometric characteristics. Moreover, it was observed that PEL during an eggbeater kick under external loads is depended on both the frequency of the legs and the anthropometrics; but the latter seem to be more significant predictors of PEL during an eggbeater kick.

A basic finding of the present study is that the majority of anthropometric characteristics were moderately (r=0.38 to 0.62) but significantly associated with PEL (Table 2). Most importantly, the first multiple regression model revealed that the participants' stature and body mass accounted for 67% and 58% of the PEL total variance, respectively (Table 3). This probably implies that taller and heavier water-polo players exhibit greater performance in the eggbeater kick under external load. It seems that greater body size is an advantageous component for water-polo players in order to win several battles in which one player executes external load on another. Many studies in other team-sports have demonstrated the importance of anthropometric characteristics in performance success (Wong, et al., 2009; Van den Tillaar, et al., 2004). It has been suggested that body mass and body length affect the total energy cost of swimming (Kjendlie, et al., 2004) and that a great body size might be advantageous for water-polo players in order to obtain a better position in the pool, and to reach and control passes (Tsekouras, et al., 2005). Furthermore, it has been demonstrated that body lengths significantly correlated with throwing velocity of female water-polo players (Platanou & Varamenti, 2011).

Additionally, factor analysis revealed that apart from body mass and stature, notably anthropometrics and legs frequency play a crucial role in height maintenance during an eggbeater kick under external loads. In particular, the first factor revealed that arm length, forearm length, foot length, and bicep girth at rest and during contraction exhibited excellent loadings (Table 4). Stature, body mass, and arm length showed very good loadings and may be considered to contribute equally to the first and second factor, respectively. The fact that, although knee length is a basic anthropometric characteristic, it was selected in the second factor exhibiting excellent loading may imply that this parameter contributes significantly to PEL performance, regardless of the impact of other variables. The third regression model based on the scores from the factor analysis showed that anthropometrics play the most important role in performance during the eggbeater kick under external loads explaining together 82% of the total variance, while no significant impact for leg frequency was revealed (Table 5).

Although no significant correlation between legs frequency and PEL was observed ($r=0.35$, $p<0.05$), the first multiple regression model showed that the frequency of legs concurrently with body weight and alternatively the stature of the participants were significant predictors of PEL. In particular, it was observed that leg frequency explained 45% and 48% of the total variance of PEL in the two regression models, suggesting that the higher the leg frequency, the greater the PEL would be. Sanders (1999) found that squared foot velocity was strongly correlated with height maintenance in the eggbeater kick ($r=0.85$). The fact that the players of the present study with greater body size and knee length executed fewer leg movements during the 20-sec eggbeater kick test may be attributed to longer lower limbs, allowing them to perform a greater movement which results in a higher velocity. Accordingly, the latter seems to be very important in keeping the body in an elevated position. Moreover, it seems that players with longer lower limbs displace more mass of water per leg movement due to their greater surface area. In conclusion, the hypothesis that anthropometrics in conjunction with leg frequency affect the performance during the eggbeater kick under external loads is verified, notably anthropometrics seem to be more significant predictors.

It is known that the eggbeater kick is more a technical than a dynamic ability (Platanou, 2005). However, since the eggbeater kick was executed under increasing external loads, strength-related parameters could have affected the performance test. During a game, water-polo players often perform the eggbeater kick under external pressure. On this occasion, except for adequate technique and anthropometrics, performance may be determined by strength or physical fitness level. The players participated in the present study were well-trained athletes and as such, the maintenance of height achieved under external loads could have been determined by the participants' strength and/or fitness level. Moreover, our results cannot be applied to players with different training levels or experience. Future studies will establish whether PEL during an eggbeater kick is related not only to anthropometrics, but to the level of strength or training experience, as well.

Practical applications

The results of the present study indicate that anthropometric characteristics are more important predictors of performance during the eggbeater kick under external loads than leg frequency movement. In terms of leg frequency, coaches should target on flexibility improvement concurrently with the strength development of the muscles involved in the eggbeater kick technique. Consequently, a training schedule should comprise stretching and exercises with or without added loads during the eggbeater kick. Moreover, it seems that in talent selection, children with greater body size may be more appropriate for water-polo.

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ODNOS ANTROPOMETRIJE I FREKVENCIJE ROTACIONIH POKRETA NOGU POD USLOVIMA SPOLJAŠNJEG PRITISKA U VATERPOLU

Nameravamo da istražimo da li su specifične antropometrijske karakteristike i/ili učestalost pokreta nogu povezani sa sposobnošću vaterpolista da se odupru spoljašnjem pritisku tokom rotacionih pokreta nogu. U ovom istraživanju učestvovalo je dvadeset četiri vaterpolista. Preliminarno su izmerene antropometrijske karakteristike učesnika. Nakon toga, sproveden je 20-sekundni eggbeater kick test kako bi se utvrdilo minimalno opterećenje kome učesnici mogu da izdrže. Na dan eksperimenta, svaki učesnik je izvršio 20-sekundni eggbeater kick test, počevši od 10 kg i nakon toga sa progresivnim povećanjem spoljašnjeg opterećenja od 1 kg dok se ne postigne vršno spoljno opterećenje (PEL). Spoljašnje opterećenje kome su igrači mogli efikasno da se odupru pre nego što se neuspeli pokušaj smatra PEL. Uočene su značajne korelacije između većine antropometrijskih karakteristika i PEL (r=0,38 do 0,62, P<0,05). Višestruke regresione analize su otkrile da stas i telesna masa objašnjavaju ukupnu varijansu PEL za 67% i 58% respektivno (P<0,05), dok su učestalost pokreta nogu takođe bili značajni prediktori koji objašnjavaju više od 45% varijanse PEL (P<0,05). Faktorska analiza pokazala je da antropometrijske karakteristike i frekventni rotacioni pokreti nogu u potpunosti objašnjavaju 80,42% varijanse PEL. Međutim, analiza višestruke regresije zasnovana na rezultatima faktorske analize otkrila je da su samo antropometrijske karakteristike bile značajni prediktori PEL tokom rotacionih pokreta nogu, objašnjavajući više od 37% ukupne varijanse (P<0,05). Ova studija ukazuje na to da su antropometrijske karakteristike važniji prediktori performansi rotacionih pokreta nogu.

Ključne reči: *test performansi, vaterpolisti, telesna građa, telesna masa.*

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MOTOR ABILITIES AS PREDICTORS IN ARTISTIC SWIMMING: A CROSS-SECTIONAL STUDY

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Abstract. *The aim of this research was to examine the association between motor abilities and achievement in artistic swimmers at the national competition level. Thirty-five junior synchro swimmers (age 16 to 18 years old, height 165.49±3.57cm, and weight of 53±4.23kg) took part in the research. Motor ability evaluation comprised eleven tests for overall and two tests for specific motor abilities. The data analysis was done in SPSS 20.0. The results show a statistically significant association between the predictor system and the criteria (p=.00). The technical execution score was correlated with several physical fitness variables. A multiple regression analysis revealed that push-ups, balance with open eyes, and T2 accounted for a large part (.69%) of the variance in the final score. The results of this research are practically applicable in more qualitative preparation of synchro swimmers and achieving maximal results.*

Key words: *Physical Preparation, Competition Success, Sport-Specific Abilities*

INTRODUCTION

Successful performance in artistic swimming depends on the swimmers' ability to execute a synchronized routine of elaborate moves in water accompanied to music (Rodriguez-Zamora et al., 2014). To achieve this goal, artistic swimmers must train for aerobic and anaerobic fitness, strength, power, endurance, flexibility, performance skills, and artistic expression (Mountjoy, 1999). Similar to gymnastics and figure skating, artistic swimming implies a complex judging system that evaluates many components of skills, synchronization, and artistic impression. Among the many factors that may influence performance, morphological characteristics and physical fitness are the crucial ones (Robinson & Ferraro, 2004; Sundgot-Borgen & Garthe, 2011; Dodigović & Sindik,

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2015). Therefore, one should pay attention to the morphological status and motor abilities of artistic swimmers from the very beginning of the training process (Payn & Sharp, 2014; Dodigović & Sindik, 2015; Stanković et al., 2015). Special attention should be given to the training process and other external factors that impact the results of artistic swimmers. In order to define the model characteristics of artistic swimmers, it is necessary to establish physiological, biochemical, biophysical and all other mechanisms that determine individual differences in swimmers' motor abilities and then determine how much we can rely on the influence of these potentials.

Artistic swimming, despite its apparent ease, is a rather demanding sport, and besides serious physical preparation, swimmers must be endurable, strong, flexible, and graceful and perfectly master breath control skills (Alentejano et al., 2010; Homma, 2010; Tošić et al., 2010; Gabrilo et al., 2011; Tošić, 2011; Khosravi et al., 2013; Robertson et al., 2014). Artistic swimmers' movements include rotations around different body axes and are associated with their need to perfectly orientate themselves underwater and to achieve a high level of motor abilities (Dimitrova, 1998; Stanković, Milanović, & Marković, 2015). The performance of various techniques and formation elements includes a combination of highly complex motor actions and skills. Therefore, it is obligatory to determine motor skills and knowledge necessary for the successful performance of figures in artistic swimming. Since motor abilities affect both functional abilities and morphological characteristics, it is compulsory to develop them to the maximum. In artistic swimming, we have always strived to discover all the factors that influence and contribute to achieving better results. Motor abilities play a significant part in the results of synchronized swimming. However, their level has not been determined yet, because the result also depends on other dimensions (morphological characteristics, functional abilities, and psychological factors). Several studies in synchronous swimming relate to basic motor skills. Many authors have studied flexibility in artistic swimming, as one of the more dominant motor abilities (Yamamura et al., 1999; Perić and Spasić, 2010; Tošić, 2011). Most studies (Karpeev, 2008; Perić, 2011) suggest that motor coordination is constantly present in training from the very beginning, since a large number of repetitions occurs when practicing a particular technique. Therefore, coordination should not be specially developed because it is already contained in the primary selection of synchronous swimmers. Research related to strength training suggests that strength also causes positive changes in speed and aerobic capacity due to a more efficient movement economy in water (Hoff et al., 2002; Osteras et al., 2002). Specific motor skills represent an under-explored field in synchronized swimming. Previous studies rarely investigated the association between the competition score and physical fitness variables related to competitive achievement in artistic swimming (Perić, Zenić, Mandić, Sekulić, & Sajber, 2012). In a study conducted by Perić et al. (2012), the authors stated that sport-specific fitness tests are more convenient and applicable than standard fitness tests. Athletes are regularly interested in exercise testing that is directly related to their performance, thus we included two sport-specific tests in physical fitness testing. The results showed that both tests are reliable as diagnostic tools in the analysis of sport-specific explosive strength, and they have high applicability (Perić et al., 2012). The present study aimed at examining the correlation between selected physical fitness variables and the competition score in junior synchronized swimmers' national level in Serbia.

METHODS

Participants

Thirty-five female artistic swimmers, age 16 to 18, volunteered to participate in the present study. Based on the results of the final score at the National Competition in the organization of the National Synchro Swimming Association of Serbia, they held a national rank of competition at the moment of research. All the participants were free of injury, trained regularly (5-6 days per week, approximately 3 hours per session), had at least 5 years of experience, and took part in competitions 3-4 times per year according to the national calendar. After a detailed briefing about the experimental procedure and the potential risks involved in the study, all swimmers provided written consent to be part of the study. The study was approved by the Institutional Review Board of the Educons University, and all procedures followed the Declaration of Helsinki.

Procedures

All measurements were made in the morning hours before training and after the warm-up. Physical fitness and technical execution assessments were performed during two separate sessions 2 days apart. The anthropometric measurements were made first, and then physical fitness elements were assessed in the following order: balance, lower and upper body flexibility, muscle endurance, jumping performance, agility. A standardized warm-up (including 5 min jogging interspersed with general and specific movements of moderate-intensity, 10 min of static, and 10 min of dynamic sport-specific stretching) preceded each session.

Measures

Shoulder flexibility

The shoulder circumduction test consisted of the shoulder pass through (with a stick 2.5 cm in diameter and 165 cm in length, with a plastic holder at one end of the stick covering 15 cm of the wooden part, with a centimeter-scale with a zero point, directly to the plastic holder) while maintaining a grip as narrow as possible. The result was recorded in centimeters (cm). The task was performed three times. The forward bend test requires a forward bend of the trunk from a standing position on a bench with the legs extended. The result was recorded in centimeters. The task was performed three times (Radaš & Bobić, 2011).

Hip range of motion – Side split

The estimated total duration of the assignment for one respondent is about 1 minute. The initial position is the “prone position” with hands wide apart. The legs must be fully extended. The participant takes maximum propagation to the resistance of sitting with hands wide apart. When the participants reach the lowest possible position, the examiner measures the height from the axis of the pubis to the ground to 0.1cm. The result is the distance from the axis of the pubis to the ground in cm. The examiner is a female.

Body hyperextension

The bridge test was used to assess body hyperextension. Since the height of an athlete may affect the distance between wrists and heels, the measurement was standardized by subtracting it from the swimmer's height with arms raised (up to the wrist) and then dividing it by the height with arms raised. Donti et al. (2016) reported the ICC for body hyperextension in a sample of swimmers of the same age group, 0.89 ($p<0.01$). All flexibility measurements were taken twice and the best result was taken for further analysis (Donti, Bogdanis, Kritikou, Donti, & Theodorakou, 2016).

Balance

We used two static balance tests (balance on the preferred leg with eyes open and closed), because of the nature of the sport. Artistic swimming involves posture in static positions, so it is obligatory to have a high level of balance ability for the successful performance of technical elements. For both balance tests, testing time was maximum in that position. One examiner tested all the participants. A balance beam for testing balance was used (2 cm wide, 4 cm high, 60 cm long, fixed to a 60x30 cm thick plank in the middle). The goal was to stand with the preferred foot along the board and with hands on hips. The other foot is on the ground. The measurement begins when the participant lifts her leg, which is on the ground, and stops when she lowers the leg, falls off the board, or moves her hands (Radaš & Bobić, 2011).

The eyes-closed test starts when the participant closes her eyes, and the test ends when she falls off the beam, touches the floor or beam with the other leg, opens her eyes, or has visible disturbances of balance. The average result of three measurements is the final result of the balance test.

Upper-body muscular endurance

Muscular endurance of the arms and chest muscles was measured using the 1 min push-ups test. The participant was in a prone position on her toes and hands. The hands were placed shoulder-width apart with the fingers pointing forward. The elbows were held in full extension and the feet were placed 10 cm apart. The swimmers were instructed to keep the body in a straight position and bend their elbows until the chin touched the mat and then fully extended their arms again. The maximum number of push-ups performed consecutively in one minute was used for further analysis. Donti et al. (2016) reported ICC for the 1 min push-ups test was 0.91 ($p<0.01$). For muscular endurance, the participant performed as many repetitions as possible using maximum speed throughout the test. The test was stopped if two consecutive repetitions were unsuccessful or if the participant was unable to continue. An unsuccessful repetition was regarded as one that deviated from the standard procedure. The maximum number of push-ups was documented to evaluate muscular endurance (Augustsson et al., 2009).

Muscular endurance of the abdominal muscles

Testing of the muscular endurance of the abdominal muscles included sit-ups. The swimmers lay face up on a mat with their knees bent at 90° and crossed their arms over their chest with their hands on their shoulders at all times. From this position, they raised the upper torso until their elbows touched their knees and then lowered their upper torso until their shoulder blades touched the floor. The examiner assisted by anchoring the swimmer's feet on the ground. The maximum number of correctly executed repetitions was recorded (Radaš & Bobić, 2011; Donti et al., 2016).

Isometric Back Extension Endurance Test

Endurance was evaluated by timing (holding time measured in seconds) how long the participant could hold the upper part of the body horizontal, while lying prone, with no support beyond the upper border of the iliac crest. The hands were kept behind the neck and the thighs and ankles were fixed to the table by 2 wide straps. The participants were instructed to hold the position as long as they could. Coefficients of inter-tester reproducibility for holding time ranged from 0.66 to 0.89 in earlier studies (Augustsson et al., 2009).

Jumping performance – The Standing Long Jump

The athlete stands behind a line marked on the ground with feet slightly apart. A two-foot take-off and landing are used, with the swinging of the arms and bending of the knees to provide forward drive. The participant attempts to jump as far as possible, landing on both feet without falling backward. A better result from two attempts is evaluated, with an accuracy of one centimeter. The test-retest reliability in previous studies varies from 0.91-0.96 (Manske & Reiman, 2013).

Speed and Agility – The Sport-specific motor test
("Sprint freestyle" 25m + diving 25m with barracuda and boost at 12.5m (T1))

In the starting position, the swimmer holds the pool wall with one hand and the other hand in the forward position on the water surface, while the feet are placed on the pool wall. At the sign, the swimmer responds with a somber reflection, followed by a short glide through the water. Towards the end of the slide (when the slowing begins), the swimmer works with her feet and hands using the trail technique. In this swimming technique, the legs alternate downward strokes. On impact, the movement begins with the leg bent and returns with the leg extended. In the trail case, arms alternate with the curves in such a way that they are bent at the elbow, while one hand pushes the water backward, while the other returns through the air to the "upset" position. Because swimmers swim at full speed ("sprint"), they do only 4 to 5 breaths on a 25m section. After 25m, swimmers touch the wall of the pool, take a breath, dive, and push away from the wall with a sultry reflection. After pushing, the swimmer glides through the water and dives with free technique (underwater breaststroke technique), up to half of the specified length of diving. At 12.5m, swimmers turn to the "back pike" position (hull and legs close a 45 ° angle, and the feet are perpendicular to the surface of the water with their feet), to prepare for the "Barracuda" water jump. After the boost, once they breathed in, the swimmers dive and continue their free-diving dive to the pool wall (to the starting point of measurement). The shorter the runtime, the better the result. Propulsive techniques and postures of the body in motion are such that they allow swimmers to move as fast as possible at all times. This is a problem, and there are no performance errors that cause a swimmer to repeat the test. The test was designed with the idea that swimmers, after high-intensity work, have apnea work, in this case diving, which will be interrupted by asynchronous elements. To break this section, 2 elements of explosive power were used in this test. In one element, swimmers do not breathe and in the other, they take one breath. Similar situations occur during the execution of figures (Perić, 2011).

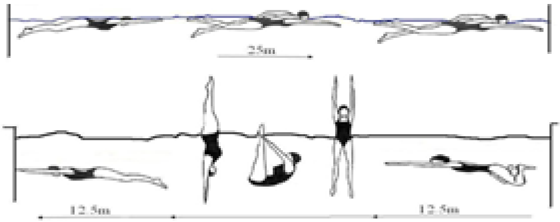

Fig. 1 "Sprint freestyle" 25m + diving 25m with barracuda and boost at 12.5m (T1)

Endurance – The Sport-specific motor test ("Flutter kick" 25m + diving 25m (T2))

Test T2 is performed in such a way that the swimmer crosses 25m using the propulsion technique "leg bike" and then dives 25m freestyle. The "foot bike" is an integral part of arriving at the panel of judges during the figure competition. It is one of the basic propulsive techniques in synchronization and has been included in newly constructed tests. The body is upright in the water with the characteristic position of the legs and arms whose alternating circular motion allows movement while the shoulders and head are above the surface of the water. In this position, the swimmer can move in various directions (forward, lateral and backward, and even diagonally). The lateral movement is the one that is performed most quickly and is therefore assigned in this test. The height of the shoulders above the surface of the water is determined by the swimmer's intensity. The higher the shoulders are above the water, the more intense arm and leg work is required to maintain it. Therefore, it was determined that when performing the test, only the upper part of the shoulder should be above the water surface to have an optimal speed-to-height ratio. The initial position of the body is similar to that of movement, except that the intensity of work is much lower, and the arms are stretched out so that the swimmer once held to the pool wall. At the sign, the swimmer detaches herself from the wall and moves with intense work, moving to her dominant side. After 25m of this technique, the swimmer touches the pool wall by hand, dives, pushes away from the wall with a sulfurous reflection, and dives 25m with a free technique (underwater breaststroke technique). The technique of underwater chest curling is performed in such a way that the arms curl while the arms are bent at the same time. While extended, the arms pull water backward in a semi-circular motion, all the way to the hip line. When the bandage ends, the palms in front of the chest and face are drawn as briefly as possible until re-arming. The legs push the water backward in a semi-circle. Thus, the feet are open to the outside and are attracted to the lower legs. The knees extend, but do not extend beyond the feet. At the end of the impact, the legs are assembled and are extended. When preparing the legs for impact, the lower legs bend so that they can strike. This way the "extended" curtain allows for a slight glide through the water. The depth at which the dive is arbitrary is in the lower half of the depth of the basin (usually closer to the bottom of the basin). With such diving techniques, swimmers control the depth well, can change their body position quickly, and do not have enough space for any errors that would affect the test time. Underwater thoracic swimmer techniques go faster than a given section (faster dives) and are less tired than diving with the “trail leg” technique. The test measurement time stops when the swimmer, after the dive section, touches the edge of the pool with a hand (Perić, 2011).

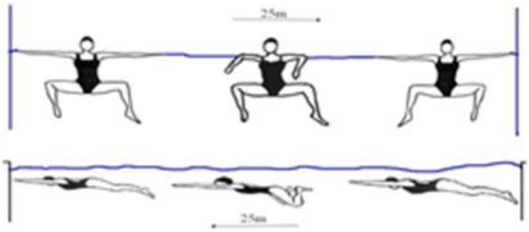

Fig. 2 "Flutter kick" 25m + diving 25m (T2)

The criterion variable is the final result (RANG) of the National Artistic Swimming Championship according to FINA rules (2013-2017).

Statistical analysis

Data processing was performed in the program SPSS 20.0. and reported as means and standard deviations (SD). Pearson's correlation coefficient (r) was used to detect associations among variables and the final score. A multiple regression analysis was used to investigate which physical fitness variables contributed most significantly to the technical execution score. Statistical significance was at $p<.05$. All analyses were performed using SPSS (version 20.0, SPSS Inc., Chicago, IL, USA).

RESULTS

The results of descriptive statistics and Pearson correlation analysis are shown in Table 1. The results of a correlation analysis showed big correlations between rank at the competition and ten of the 13 variables.

Table 1 Descriptive Statistics and Pearson correlations

Variables	Minimum	Maximum	Mean	SD	Rang
Side split	-44.00	22.00	-3.66	16.84	-.408*
Shoulder flexibility	15.00	98.00	54.24	19.04	-.327
Sit and reach	7.00	29.00	17.69	5.49	.484**
Long distance jump	141.00	192.00	164.83	11.76	-.163
Bridge	11.00	61.00	38.57	14.32	-.303
Endurance abs	3.00	50.00	13.00	8.77	.416*
Endurance back	78.00	206.00	126.40	32.37	.366*
Balance eyes open	3.00	27.67	12.91	5.79	.619**
Balance eyes closed	7.67	60.00	36.33	16.31	.528**
Push-ups	6.00	25.00	13.14	4.19	.620**
Sit-ups	18.00	32.00	24.51	3.43	.443**
T1	62.00	88.00	72.11	6.85	-.428*
T2	47.00	69.00	55.86	5.49	-.514**
RANG	45.09	63.59	53.40	4.26	-

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 2 Results of the multiple regression analyses using physical fitness variables as predictors of the performance final score

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	F	Sig.
1	.829[c]	.687	.657	2.499	22.663	.000

Predictors: Push-ups, Balance with open eyes, T2
Dependent variable: Rang

Table 2 shows a statistically significant relationship between the predictor system and the criteria (p=.00). The technical execution score was correlated with several physical fitness variables. Multiple regression analysis revealed that push-ups, balance with open eyes, and T2 accounted for a large part (.687%) of the variance in the final score.

DISCUSSION

The present study aimed at examining the association between selected physical fitness variables and the competition score in junior synchronized swimmers at the national level. The participants for this study were taken from the population of female swimmers aged 16 to 18. The relationship between the variables for the evaluation of motor abilities and the dependent variable of the ranking is high, so the battery used for the evaluation of their motor abilities is good. The results of the regression analyses confirmed the larger contribution of motor abilities to the variance in the competition score.

The research showed that the highest predictive power for evaluating is related to upper-limb endurance, balance, and the first sport-specific test used to determine the endurance of swimmers. The test was designed with the idea that female swimmers, after very intensive work (diving in this case), have apnea which will be interrupted with a synchro-element. The elements that require explosiveness from female swimmers also require additional effort (with or without breathing) and are easy to control, so they were included in this test. Test T2 contains diving at 25m. Although the freediving training and breathing exercises start on land, the best training is diving in different time intervals and at various depths. The most demanding part of performing figures is the training in apnea, where the muscles work without oxygen, which is also the reason for such a large impact of the specific motor skills on the ranking. The participants with poorer measurement results regarding the speed of element performance in test T1 are also the ones that are, according to the subjective opinion of the coach, “lower-ranked female swimmers.” At the same time, the tests which measure the strength of the participants also partially represent their performance technique. The participants with a better result in tests T1 and T2 are also “higher-ranked female swimmers” since their better techniques offer greater utilization of strength (Perić, 2010).

Such results can be attributed to intensive motor training abilities which are especially expressed in the achieved final placement of swimmers. Research has shown that the greatest predictive power for performance evaluation figures has standing tests on one leg along the balance bench and push-ups. Such results are expected, given the specifics of the figures performed at competition. This is supported by previous research that suggests that stability and balance of the body and quality rowing with the hands is necessary for achieving good results in the figures (Homma et al., 2014). Hand strength is an obligatory code for performing all the figures in artistic swimming. Those motor abilities are statistically significant for achieving high sports results, according to the research of the author Labudova (2014). In younger participants, the most significant contribution in the space of motor abilities is realized in the space of endurance, dynamic strength, and static and explosive forces of the upper extremities. Positive changes and a better economy of movement in the water in synchronous swimming allow a higher level of strength. Research results of a large number of authors show that synchronous swimming is a sport that requires strength (Chu, 1999; Hoff et al., 2002; Osteras et al., 2002), but also a high level of flexibility (Tošić et al., 2010).

Analyzing the performances of various elements of technique and composition in synchronous swimming, it can be seen that movements in this sport represent a combination of highly complex motor actions. Therefore, it is compulsory to determine the motor skills and knowledge needed for the successful performance of figures in synchronous swimming. As motor abilities affect both functional abilities and morphological characteristics, it is necessary to develop them to the maximum. Due to the acrobatic elements that are an integral part of the choreography, synchronous swimmers face increasing and more specific requirements (Chu, 1999). The results of many studies undoubtedly confirm the fact that motor skills have a great impact on performing swimmers (Yamamura et al., 1999; Perić & Spasić, 2010; Tošić et al., 2010; Stanković et al., 2015).

CONCLUSION

Based on the results, we can draw several conclusions. Firstly, all research fields significantly affect the final result of female swimmers in terms of statistics. However, the obtained results refer only to the researched sample of participants. Although this is a selected sample, it is obvious from the descriptive statistics that the participants differ significantly on the individual level, both in terms of motor and specific abilities. The research should focus on the analysis of the body composition of a large number of female swimmers, as well as that of female swimmers of other age groups. The motor and specific motor skills directly affect the final result. The obtained results suggest that the motor and the specific motor skills of female artistic swimmers yield better results. Therefore, it is necessary to work on their improvement to achieve good results. The results can have a wide practical application in the physical and technical preparation of female swimmers. It is a fact that the further progress of science will enable us to gain a better understanding of the functioning of female artistic swimmers' bodies. The discovery of new scientific achievements in the framework of this sport or the use of better training means shall contribute to the ever-improving preparation of female athletes, thus enabling the achievement of top results.

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MOTORIČKE SPOSOBNOSTI KAO PREDIKTORI U UMETNIČKOM PLIVANJU: STUDIJA PRESEKA

Cilj ovog istraživanja bio je da se ispita povezanost motoričkih sposobnosti i postignuća kod umetničkih plivača koji se takmiče na republičkom nivou. U istraživanju je učestvovalo 35 juniorskih sinhronih plivača (uzrasta od 16 do 18 godina, visine 165,49±3,57cm i težine 53±4,23kg). Evaluacija motoričkih sposobnosti obuhvatala je jedanaest testova za ukupne i dva testa za specifične motoričke sposobnosti. Analiza podataka je urađena u SPSS 20.0. Rezultati pokazuju statistički značajnu povezanost između prediktorskog sistema i kriterijuma (p=.00). Rezultat tehničkog izvršenja bio je u korelaciji sa nekoliko varijabli fizičke spremnosti. Višestruka regresiona analiza je otkrila da sklekovi, ravnoteža sa otvorenim očima i T2 čine veliki deo (.69%) varijanse u konačnom rezultatu. Rezultati ovog istraživanja su praktično primenljivi u kvalitetnijoj pripremi sinhronih plivača i postizanju maksimalnih rezultata.

Ključne reči: *fizička priprema, uspeh na takmičenju, specifične sposobnosti*

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Research article

THE ASSOCIATION BETWEEN INTENSITY AND DIRECTION OF COMPETITIVE ANXIETY WITH PRE-PERFORMANCE EXPECTATIONS AND COMPETITION PERFORMANCE

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Abstract. *During sports competitions athletes experience anxiety, frequently intense, which can affect performance and well-being. The first aim of this study was to test the predictive power of pre-performance expectations for intensity and direction of multidimensional components of state anxiety. The second aim was to test the predictive power of direct and interactive effects of intensity and direction of anxiety symptoms on performance. The sample consisted of female basketball athletes (N= 58) with an average age M=15.68±.99 and average sport experience M=5.85±2.23, during the final tournament. Within an hour before the match, they completed the CSAI-2, CSAI-2-d, three single items about performance expectations, and four single items addressing performance assessment. After the match, the players answered three single items aimed to assess performance. After the match the teams' head coaches (n=5) also assessed individual player's performance. The regression analysis revealed that Expectation of a good performance emerged as the only negative predictor of Intensity of cognitive anxiety, Intensity of somatic anxiety, and positive predictor of Intensity and Direction interpretation of self-confidence. Only the Intensity of cognitive anxiety is a negative predictor of Satisfaction with performance. The obtained results suggest that dominance of Expectation of a good performance can be possibly viewed as a protective factor that has the potential to decrease anxiety and increase self-confidence and perceived self-confidence as more facilitative to performance. Other tested predictions of anxiety-performance measures are not significant. More studies are needed to investigate other potential antecedents and moderators of anxiety components. Also, further empirical development of performance measures and tests of anxiety-performance relationships would enhance comprehensive understanding of such complex relationships.*

Key words: *Performance, Pre-performance expectations, Post-performance measures, Intensity of state anxiety, Directional interpretation of anxiety*

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1. INTRODUCTION

Competitive performance is affected by various psychological factors (Mytskan et al. 2006). Undoubtedly, participating in sports competitions, athletes often feel a variety of emotions, pre-competitive anxiety being one of the prominent one (Jones & Hanton, 1996; Ford, Ildefonso, Jones, & Arvinen-Barrow, 2017). Various theoretical models and theories about the mechanisms that are below the surface of relationships between anxiety and performance have emerged. One of the leading is Martens' multidimensional model (Martens, Burton, Vealey, Bump, & Smith, 1990). A fundamental premise of the model is that competitive anxiety is multidimensional in nature. Two components of anxiety can be distinguished: a mental component termed cognitive anxiety (e.g. worry and negative thoughts) and a physiological component termed somatic anxiety (e.g. increasing heart rate, sweating, tight muscles, butterflies in the stomach, etc.). It is proposed that these two anxiety components affect athletic performance differently. Cognitive anxiety is seen as a component which negatively affects athletic performance, whereas somatic anxiety is considered a component which influences athletic performance in a non-linear manner (too low and too high levels have harmful effects). It is assumed that these two subcomponents are related to environmental factors that affect perceptions of success and failure. The third component of the model is self-confidence (positive expectations of success), which is not an aspect of anxiety, but its absence or low intensity might indicate that athletes experience cognitive anxiety. Progress in this field was also stimulated by the development of the Competitive State Anxiety Inventory-2 (CSAI-2), which measures the "intensity" of pre-competitive state anxiety symptoms and self-confidence (Martens, et al., 1990) and which became one of the most frequently used instruments. Therefore, extensive research was devoted to exploring the effects of anxiety components on competition performance (Peng & Zhang 2021). In sum, existing empirical findings conducted in different sport settings are equivocal. Some studies confirm theoretical assumptions that higher levels of competitive cognitive anxiety have negative effects on performance success (Kleine, 1990; Woodman & Hardy, 2003). Contrarily, other research findings do not confirm theoretical assumptions, and suggest that anxiety has the potential to improve competitive performance (Hanin, 2007). In line with these research results, that anxiety potentially can enhance performance, are findings presented in a meta-analysis (Woodman & Hardy, 2003) which indicated that 40% of research results do not confirm the harmful effects of cognitive anxiety. Contrary to theoretical predictions, almost a quarter of the reported results in that analysis indicated that cognitive anxiety has the potential to improve competitive performance. Furthermore, according to some empirical results that are included in Woodman and Hardy meta-analyses (2003) and in Craft's and collaborators' meta-analyses (2003), anxiety-performance relation is weak, and self-confidence appears to be a better predictor of competitive performance than anxiety.

An important issue, that can help to develop an effective intervention technique, is the identification of factors that antedate and/or evocate competitive anxiety. Martens assumed that antecedents of cognitive anxiety and self-confidence involve environmental factors primarily associated with athletes' expectation of a successful performance. It is hypothesized that an increase in performance expectations, as well as uncertain expectations, are related to an increase in cognitive anxiety and decrease in self-confidence. On the other hand, somatic anxiety antecedents are evoked by factors that are different in nature - nonevaluative and are dominantly based on conditioned stimulus, like the locker room, pre-game routine (Jones, Swain, & Cale, 1990). It is surprising that detailed empirical examinations of the antecedent of multidimensional anxiety component (their intensity and directional interpretation of symptoms) in different sports contests still did not get more research attention. In general, results of few studies are congruent in conclusions that three components of the multidimensional state anxiety have some common antecedents, but also each component has some unique ones (Gould, Petlichkoff, & Weinberg,1984; Jones, et al., 1990; Lane, Terry, & Karageorghis, 1995).

Further theoretical advances and contribution to a comprehensive understanding of the anxiety-performance relationship were initiated by work of Jones and Swain (1992). Considering the existence of ambiguous research results, they hypothesized that the "intensity" approach dominated as a result of anxiety mainly being observed as negative to performance (Jones, 1995). The authors extended the intensity approach by introducing the notion that the directional interpretation of anxiety symptoms is significant. Athletes may perceive anxiety symptoms as positive i.e. facilitative or negative i.e. deliberative in relation to performance. In other words, a higher degree of cognitive anxiety is not necessarily harmful to performance. If athletes interpret symptoms as facilitative, higher intensity of cognitive anxiety can improve performance (Jones, Swain, & Hardy, 1993; Hatzigeorgiadis, & Biddle, 2008). Additionally, authors adapted the original version of the CSAI-2 (Jones & Swain, 1992), by adding a directional interpretation of anxiety symptoms subscales along with intensity subscales. Afterwards, a series of investigations were conducted to test this hypothesis (Jones & Swain,1992; Jones, et al., 1993; Jones, Hanton, & Swain, 1994). Overall, the results confirmed the hypothesis that anxiety effects can be perceived as positive and negative in relation to performance. Also, successful performance, in comparison with unsuccessful performance, was linked with a more facilitative and less debilitative interpretation of anxiety. According to Mellalieu and associates (Mellalieu, Hanton, & O'Brien 2004) numerous subsequent research showed that elite athletes in comparison with non-elite experience a similar intensity of anxiety symptoms, but concurrently, interpret the perceived symptoms as more facilitative.

Another crucial issue is the eligibility of performance measurement that should not be neglected due to its influence on anxiety-performance research results. Within sport psychology, numerous studies were aimed at investigating the relationship between different psychological variables (e.g. anxiety, emotions, coping) and competition performance. Bearing in mind that athletic performance is complex and that there is no universally suitable measure of performance that could reliably capture all important aspects of performance, it is not surprising that researchers used different approaches to performance evaluation (objective and subjective assessment), and a variety of concrete performance measures. Objective measures of performance were based on achieved result score, like performance time, the number of shots, performance time (Nicholls, Taylor, Carroll, & Perry, 2016). In team sports (Kais & Raudsepp, 2005), absolute outcomes of the game – win and loss, were frequently used. Authors argue that such global measure can obscure the anxiety-performance relationship because individual differences, like differences in player position in the team, are not taken in consideration. To overcome the previously mentioned weaknesses of the applied measures, other scholars used subjective measures of performance. These types of measures are commonly based on athlete's pre- and post-performance self-assessments. For example, goal attainment expectancy (O'Brien, Hanton, & Mellalieu, 2005) is used as indicator of the pre-performance subjective self-assessment measure. Common post-performance subjective measures are goal attainment (Gaudreau & Blondin, 2004; Schellenberg, Gaudreau, & Crocker, 2013), and performance satisfaction (Nicholls, Polman, & Levy, 2012; Polman, Rowcliffe, Borkoles, & Lev, 2007; Nicholls, Taylor, Carroll, & Perry, 2016). Having in mind that the athlete's self-assessment bias is highly conditioned by the emotions related to the competitive result, in some research (Kais & Raudsepp, 2005) performance assessment by the coach was applied. The rationale for this approach is the fact that the coach is an expert who is familiar with the potentials and limitations of his athletes. To overcome the aforementioned limitations, some authors (Butt, Weinberg, & Horn, 2003) combined both types of measures, a players' self-assessment and a head coaches' player performance assessment.

Based on their empirical findings, some authors (Lane, et al., 1995) concluded that stressors that provoke anxiety vary across different sports (and some of them are unique for each sport discipline). They recommended that existing research results should be extended by investigating state-anxiety antecedents across different sports. As far as we know, antecedents of state anxiety components in basketball have not been the focus of previous researchers. Therefore, the first aim of this study was to investigate the predictive power of performance expectation on intensity and directionality interpretation of cognitive anxiety, somatic anxiety, and self-confidence. Taking into account equivocal results on anxiety-performance relationship, the second aim of this study was to investigate direct and interactive effects of intensity and directional interpretation of anxiety symptoms on performance, measured by players' subjective post-performance assessment and also by a head coaches' assessment of individual player's performance.

2. METHOD

2.1. Sample

The sample consisted of 58 Serbian female basketball players who competed in the Final cadet women's league tournament in 2021 (five of the six clubs that competed). They were 12-17 years old (*M* = 15.68 SD = .99), and had 2-11 years of experience in sport (*M* = 5.85, SD = 2.23). The subsample of coaches consisted of five head coaches of the teams.

2.2. Instruments

The Competitive State Anxiety Inventory-2– CSAI-2 was applied to assess the intensity of competitive state anxiety. CSAI-2 is a self-reporting instrument created by Martens and associates (Martens, et al., 1990), and was used to examine the intensity of precompetitive anxiety symptoms. The instrument consists of 27 items classified into three subscales (nine items per scale): cognitive anxiety ("I have self-doubts."), somatic anxiety ("I feel tense in my stomach.") and self-confidence ("I'm confident about performing well"). The participants were asked to rate the intensity of each item on a four-point Likert type scale (from 1 "not at all" to 4 "very much so"). The score range for each subscale is 9 – low score, to 36 – high score.

The directional interpretation of anxiety symptoms scale CSAI-2-d is a modified version of the CSAI-2 by Jones and Swain (1992). Each item from this scale corresponds to each item of the CSAI-2. The participants rated the degree to which perceived anxiety symptoms and self-confidence were either facilitative or debilitative to their performance. Items are ranged on a 7-point Likert scale, from –3 (very debilitative) to +3 (very facilitative), and 0 as unimportant. Potential direction scores ranged from –27 to +27.

Pre-performance expectations. The participants rated their expectations related to performance, answering the three following statements: “I expect to play well in this match”, “I expect that we will win this match”, “I expect this match to be hard”, in the form of a 10-point Likert scale from 1 (Completely Disagree) to 10 (Completely Agree).

Post-performance assessment. Players rated their current performance (subjective self-assessment of performance) answering the three following statements: “I am satisfied with how I performed at the match”, “Today, I fulfilled the goals I set”, “Today, I fulfilled the perceived goals set by coach”, in the form of a 10-point Likert scale from 1 (Completely false) to 10 (Completely true). The head coaches of the teams were asked to rate individual player’s performance (subjective assessment of performance by significant other) answering the statement “Today she performed during the game as well as usual”, on a 10-point Likert scale from 1 (Completely False) to 10 (Completely true).

2.3. Procedure

The research was conducted during the Final cadet women's league tournament – Triglav, in May 2021. The questionnaires were conducted in paper-and-pencil form by a researcher. First, within 1 hour before the match the participants provided socio-demographic information (age, sex, length of sport experience), intensity and directional CSAI-2, and then answered questions about their performance expectations. This first part of the questionnaire lasted about 10 minutes. Immediately after the match, the participants completing the questions addressing self-evaluate performance. This part of the questionnaire lasted on average less than 5 minutes. The participants were informed about the purpose of the study and gave informed consent. Also the head coach of the team, after the match, rated the performance of individual players during the match.

2.4. Statistical Analysis

The preliminary statistical analysis included Cronbach’s alpha coefficients of reliability and descriptive statistics (*M*, *SD*). Then, a correlation analysis (Pearson correlation) was applied to test the association between all dimensions of anxiety intensity and directional interpretation of anxiety, pre-performance expectations, post-performance self-assessment, and coach's post-performance assessment of individual player’s performance. Two series of regression analyses (enter method) were conducted. First, two linear regressions (enter method) were applied to test the predictive power of pre-performance expectations, on all three components of anxiety intensity, and second, on all three components of directional interpretation of symptoms. After that, three hierarchical regression analyses (enter method) were applied to test the direct and interactive effect of intensity and directional interpretation of anxiety symptoms and self-confidence (predictors variables) on performance. In the first analysis, the criterion variable was Satisfaction with one’s own performance, in the second, Fulfilment of personal goals, and in the third Fulfilment of perceived goals set by the coach. In the all three analyses the same set of predictors was used. In Step1, the independent predictor variables were the intensity of anxiety subcomponents (cognitive anxiety, somatic anxiety, self-confidence). For Step 2, a directional interpretation of both anxiety subscales and self-confidence were added. In Step 3 interaction effects between the intensity of cognitive anxiety and its directional interpretation, the intensity of somatic anxiety and its directional interpretation, and self-confidence intensity and its directional interpretation (three interactions) were added. Before the interactions were calculated, the data were centred.

3. RESULTS

3.1. Descriptive Statistics

Cronbach's alpha coefficients of reliability for intensity and directional interpretation of anxiety subscales were in the range from acceptable to excellent (with nine items for each subscale): for the intensity of cognitive anxiety α =.90, somatic anxiety α =.85 and self-confidence α =.87, for the directional interpretation of cognitive anxiety symptoms α =.89, for the directional interpretation of somatic anxiety symptoms α =.78, for the directional interpretation of self-confidence α =.92.

Descriptive statistics revealed that female basketball players had higher scores on Self-confidence intensity subscale (*M*=26.49 *SD*= 5.58) than on cognitive (*M*=18.69 *SD*=6.26) and somatic (*M*=16.42 *SD*=5.46) anxiety intensity subscales. Thereby, Cognitive anxiety showed a higher intensity rating than Somatic anxiety. Both Cognitive (*M*= -3.20 *SD*=8.18) and Somatic anxiety (*M*= -1.15 *SD*=7.09) directional interpretation subscales had negative mean scores, through which Cognitive anxiety was rated as less facilitative to performance than Somatic anxiety. Only the Self-confidence directional interpretation subscale (*M*=8.88 *SD*=11.84) had a positive mean score and was rated as facilitative to performance. Mean values of the variables addressed to estimate pre-performance expectations of players had the following descending rank: Expectation of winning (*M*=8.66 *SD*= 2.04), Expectation of a hard match (*M*= 8.34 *SD*= 2.28), followed by Expectation of a good performance (*M*=7.1 *SD*= 2.33).

3.2. Correlation Analysis

Table 1 presents the Pearson correlation between anxiety intensity dimensions, directional interpretation of anxiety symptoms, pre-performance expectations, post-performance self-assessment, and coach's assessment of the individual player's performance. Inter-correlations among the three anxiety intensity scales can be classified as large. Correlation between intensity and directional interpretation of the cognitive anxiety scale, as well as between intensity and directional interpretation of somatic anxiety scale, is negative (medium in size), whereas the correlation between intensity and directional interpretation of the self-confidence scale is positive and can be classified as large. The expectation of a good performance is in negative correlation with cognitive and somatic anxiety and is large positive for both the self-confidence intensity and self-confidence directional scale. There are no significant associations between Expectation of winning and anxiety components. Expectation of a hard match is in a low negative correlation with intensity of cognitive anxiety and a moderate positive one with direction of somatic anxiety. Satisfaction with one's own performance is in low negative correlation with the intensity and interpretation of cognitive anxiety. Fulfilment of personal goals negatively correlates with the intensity of cognitive and somatic anxiety. From all possible inter-correlations between pre-performance assessment (five possible), only two are positive (medium intensity): the expectation of a successful performance is in a positive association with the expectation of winning and with the expectation of a hard match. The correlation between self-assessment measures of performance is highly positive. Coaches' assessment of individual player's performance is in a negative correlation with intensity of cognitive anxiety (low intensity), and moderately correlated with satisfaction with one's own performance and also with fulfilment of personal goals. A high positive correlation exists between fulfilment of perceived goals set by the coach and coach assessment.

Table 1 Correlations between intensity and interpretation of competitive state anxiety and subjective pre- and post- performance self-assessment

	ICA	ISA	ISC	DCA	DSA	DSC	EGP	EW	EHM	SP	FPG	FCG	CAP
ICA	1												
ISA	.70**	1											
ISC	-.73**	-.70**	1										
DCA	-.31*	-.31*	.28*	1									
DSA	-.36**	-.35**	.36**	.73**	1								
DSC	-.57**	-.37**	.58**	.25	.38**	1							
EGP	-.46**	-.40**	.55**	.18	.05	.51**	1						
EW	-.16	-.15	.13	.00	-.03	.10	.44**	1					
EHM	-.28*	-.13	.24	.22	.15	.33*	.32*	-.10	1				
SP	-.30*	-.26*	.08	-.10	-.04	.04	.20	.02	.07	1			
FPG	-.23	-.25	.09	-.06	-.04	-.01	.18	-.08	.04	.82**	1		
FCG	-.33*	-.37**	.22	.05	.04	.04	.19	.05	.03	.80**	.84**	1	
CAP	-.27**	-.26	.14	-.11	.11	.08	.12	-.06	.09	.49**	.48**	.53**	1

Legend: ICA - intensity of cognitive anxiety; ISA - intensity of somatic anxiety; ISC - intensity of self-confidence; ICA – interpretation of cognitive anxiety; DSA - direction of somatic anxiety; DSC - direction of self-confidence; EGP - expectation of a good performance; EW - expectation of winning; EHM - expectation of a hard match; SP - satisfaction with one's own performance during the match; FPG - fulfilment of personal goals; FCG - fulfilment of perceived goals set by coach; CAP - coach's assessment of performance *-p<.05, **-p<.05.01.

3.3. Regression Analysis

The first series of linear regression analyses (Table 2) was applied to determine the predictive value of the pre-performance expectations (Expectation of a good performance, Expectation of winning, Expectation of a hard match) for the intensity of competitive state anxiety and self-confidence. The second series of linear regression analyses (Table 2) was applied to determine the predictive value of the pre-performance expectations (Expectation of a good performance, Expectation of winning, Expectation of a hard match) for the directional interpretation of both components of the competitive state anxiety and self-confidence.

Table 2 Multiple regression analysis: prediction of competitive anxiety and self-confidence intensity and interpretation of symptoms based on pre-performance expectations

	Intensity of cognitive anxiety			Intensity of somatic anxiety			Intensity of self-confidence		
Pre-performance expectations	*β*	*t*	*p*	*β*	*t*	*p*	β	*t*	*p*
Expectation of a good performance	-.41	-2.86	.01	-.42	-2.79	.01	.60	4.46	.00
Expectation of winning	-.00	-.01	.10	.03	.21	.83	-.13	-1.01	.32
Expectation of a hard match	-.15	-1.16	.25	.01	.07	.95	.03	.27	.79
	Direction of cognitive anxiety			Direction of somatic anxiety			Direction of self-confidence		
Pre-performance expectations	*β*	*t*	*p*	*β*	*t*	*p*	β	*t*	*p*
Expectation of a good performance	.02	.13	.90	.14	.89	.38	.51	3.70	.00
Expectation of winning	-.02	-.16	.88	-.05	-.31	.76	-.10	-.80	.43
Expectation of a hard match	.14	.96	.34	.17	1.21	.23	.16	1.25	.22

The results of the first series of simple linear regression analyses (Table 2) showed that the regression function in which the criterion variable intensity of cognitive anxiety was significant, $R = .48$, R2 = .23, $F(3, 55) = 5.49$, $p = .00$, with the only negative predictor being the expectation of a good performance. The regression function in which the criterion variable intensity of somatic anxiety was significant, $R = .40$, $R^2 = .16$, $F(3, 55) = 3.55$, p = .00, with the only one negative significant predictor being the expectation of a good performance. The third regression function in which the criterion variable intensity of self-confidence was significant, $R = .57$, R2 = .32, F(3, 55) = 8.76, $p = .00$, and again the only significant predictor being the expectation of a good performance. The results of the second series of regression analyses (Table 3) showed that the regression function in which the criterion variable's directional interpretation of cognitive anxiety was not significant, $R = .15$, $R^2 = .02$, F(3, 55) = 5.49, $p = .74$; the regression function in which the criterion variable's directional interpretation of somatic anxiety was not significant, $R = .15$, $R^2 = .02$, $F(3, 55) =.42$, $p = .74$. The third regression function in which the criterion variable directional interpretation of self-confidence was significant, $R = .55$, R2 = .30, $F(3, 55) = 7.80$, $p = .00$, and the only significant predictor was the expectation of a good performance.

The second series of four independent hierarchical multiple regression analyses (Table 3) was applied to determine the predictive value of the competitive state anxiety and self-confidence for the post-performance assessment (Satisfaction with one's own performance, Fulfilment of personal goals, Fulfilment of perceived goals set by the coach and Coach's assessment of individual player's performance). The first block included both components of anxiety intensity and self-confidence intensity, the second block included the interpretation of anxiety symptoms, and the third block included interaction between the intensity of cognitive anxiety and directional interpretation of cognitive anxiety, the intensity of somatic anxiety and directional interpretation of somatic anxiety, and the intensity of self-confidence and directional interpretation of self-confidence (3 in total).

Table 3 Hierarchical multiple regression analysis: prediction of post-performance assessment based on competitive anxiety and self-confidence intensity, interpretation of symptoms and their interactions

	Satisfaction with one's own performance				Fulfilment of personal goals				Fulfilment of perceived goals set by coach				Coach's assessment of performance			
	ΔR²	*β*	*t*	*p*	Δ*R²*	β	*t*	*p*	Δ*R²*	β	*t*	*p*	Δ*R²*	*β*	*t*	*p*
Block 1	.15				.10				.17				.10			
ICA		-.20	-2.05	.05		-.13	-1.20	.23		-.12	-1.26	.21		-.27	-1.27	.21
ISA		-.15	-1.37	.18		-.17	-1.41	.17		-.20	-1.85	.07		-.23	-1.10	.28
ISC		-.22	-1.95	.06		-.16	-1.32	.19		-.11	-1.02	.31		-.21	-1.00	.32
Block 2	.07				.04				.03				.12			
ICA		-.24	-2.34	.02		-.18	-1.54	.13		-.17	-1.60	.12		-.26	-1.22	.23
ISA		-.18	-1.59	.12		-.18	-1.44	.16		-.20	-1.8	.08		-.26	-1.31	.20
ISC		-.19	-1.66	.10		-.12	-.92	.36		-.07	-.5	.57		-.17	-.80	.43
DCA		-.10	-1.42	.16		-.06	-.75	.46		-.03	-.38	.70		.39	2.06	.04
DSA		-.03	-.29	.78		-.04	-.45	.66		-.05	-.54	.59		-.54	-2.72	.01
DSC		-.01	-.14	.89		-.03	-.55	.59		-.03	-.73	.47		.04	.21	.83
Block 3	.06				.09				.09				.04			
ICA		-.24	-2.31	.03		-.15	-1.25	.22		-.17	-1.54	.13		-.28	-1.29	.21
ISA		-.19	-1.59	.12		-.21	-1.62	.11		-.21	-1.72	.09		-.18	-.79	.43
ISC		-.24	-2.05	.05		-.16	-1.23	.23		-.11	-.88	.39		-.21	-.93	.36
DCA		-.14	-1.85	.07		-.08	-1.00	.32		-.06	-.75	.46		.31	1.51	.14
DSA		-.01	-.06	.95		-.05	-.50	.62		-.03	-.37	.71		-.46	-2.15	.04
DSC		.01	.11	.91		-.01	-.22	.83		-.02	-.53	.60		.02	.09	.93
ICAxDCA		.01	.55	.58		-.01	-.61	.55		.00	.37	.72		.26	1.24	.22
ISAx DSA		-.01	-.85	.40		.00	-.03	.97		-.01	-.60	.55		-.07	-.34	.74
ISCxDSC		-.01	-1.73	.09		-.02	-2.26	.03		-.01	-1.35	.18		.01	.08	.94
Total	.28				.23				.29				.26			

Legend: ICA - intensity of cognitive anxiety; ISA - intensity of somatic anxiety; ISC - intensity of self-confidence; ICA – interpretation of cognitive anxiety; DSA - direction of somatic anxiety; DSC - direction of self-confidence; ICAxDCA – intensity of cognitive anxiety x direction of cognitive anxiety; ISAxDSA - intensity of somatic anxiety x direction of somatic anxiety; ISCxDSC - intensity of self-confidence x direction of self-confidence;

The results of the first hierarchical regression analysis with the criterion variable Satisfaction with one's own performance showed that the regression function in the first block was significant, R = .39, R^2 = .15, F(3, 55) = 3.29, p = .03. In the second block, adding directional interpretation of anxiety and self-confidence did not increase the percentage of variance explained, ΔR^2=.07, p=.24, total R = .47, R^2 = .22, F(3, 55) = 2. 40, p = .04, and intensity of cognitive anxiety, was identified as significant negative predictor. Adding interactions in the third block did not increase the percentage of variance explained, ΔR^2=.07, p=.25, total, R = .53, R^2 = .28, F(3, 55) = 2.11, p = .05, and the intensity of cognitive anxiety and intensity of self-confidence emerged as positive predictors.

The results obtained by the second hierarchical regression analysis in which the criterion variable was Fulfilment of personal goals showed that the regression function in the first block was not significant, R = .32, R^2 = .10, F(3, 55) = 1.98, p = .13. In the second block, adding directional scales, the percentage of variance explained did not increase ΔR^2=.09, p=.17, total, ΔR^2=.04, p=.46, total, R = .38, R_2 = .14, F(3, 55) = 1.42, p = .23. By adding interactions in the third block, the percentage of explained variance did not increase ΔR^2=.04, p=.17, total, R = .48, R^2 = .23, F(3, 55) = 1.58, p = .15.

The results of the third hierarchical regression analysis in which the criterion variable Fulfilment of perceived goals set by coach showed that the regression function in the first block was not significant, R = .49, R^2 = .24, F(3, 55) = 1.68, p = .12.

By adding the second block of predictors, by adding directional scales, the percentage of explained variance did not increase ΔR^2=.03, p=.54, total, R = .37, R^2 = .14, F(3, 55) = 1.42, p = .23., nor did it increase by adding interactions in the third block, ΔR^2=.04, p=.49, total, R = .48, R^2 = .23, F(3, 55) = 1.58, p = .15.

The results of the fourth hierarchical regression analysis showed that the regression function in the first block, where the criterion variable Coach's assessment of individual player's performance was not significant, R = .31, R^2 = .10, F(3, 52) = 1.90, p = .14. Adding directional scales in the second block did not increase the percentage of variance explained ΔR^2=.12, p=.07, total, R = .47, R^2 = .22, F(3, 55) = 2.89, p = .05. Also, adding interactions in the third block, the percentage of the variance explained did not increase ΔR^2=.04, p=.60, total, R = .450, R^2 = .25, F(3, 55) = 1.70, p = .12.

4. DISCUSSION

The purpose of this study was twofold. The first one was to examine the performance expectations as antecedents of the intensity of competitive state anxiety and self-confidence, and on the directional interpretation of anxiety symptoms in a sample of successful female basketball players. In addition, we wanted to examine potential directional and interactive effects of anxiety intensity and perceived effects of the symptoms (as facilitative or deliberative) on the competitive performance.

Before discussing the main results of this study, we will present several interesting observations about anxiety intensity, directional interpretation of anxiety, and correlational analysis obtained in this research. Firstly, female basketball players in our research showed a higher level of self-confidence than on both anxiety components. These results are supported by previous empirical findings (Kais & Raudsepp, 2005; Thanopoulos & Platanou, 2016). Secondly, players perceived cognitive anxiety as more intensive than somatic anxiety. There are at least two possible explanations for this, that are not mutually exclusive. The first one is Martens' theoretical assumption that antecedents of cognitive anxiety are evaluative in nature and related to the expectation of performance. The data for this research were collected during the final state tournament, immediately before an important match. Therefore, we can hypothesize that relatively uniform teams competed and this situation which is characterized by a high degree of uncertainty, and has the potential to provoke an increase of cognitive anxiety. Secondly, somatic anxiety is mainly caused by conditioned situational antecedent, for example, stimulus within the locker room, preparation of equipment, pre-game routines, coach's instructions (Jones, et al., 1990; Gould, Dieffenbach, Moffett, 2002). Similarly, due to data collection in the course of the final tournament, it can be assumed that players during the competitive season have frequently been in similar situations with similar anxiety triggers. Consequently, because of the habitational processes, their somatic response (somatic anxiety) decreased. This result is supported by results that are obtained on a sample of elite karate athletes during the final tournament (Vesković, Koropanovski, Dopsaj, & Jovanović, 2019).

Further, the correlational analysis indicated higher correlations among all three anxiety intensity subscales than presented in earlier research (Kais & Raudsepp, 2005; Jones, et al., 1990). Taking into account that our research included a relatively small number of participants and that it was not our major research question, we cannot take a final position whether our results confirm theoretical propositions about the separation of cognitive and somatic components of anxiety.

Considering the directional interpretation scale, female basketball players have perceived both anxiety manifestations as deliberative to performance. Only self-confidence has been perceived as a factor with facilitative effects upon performance. Having in mind that equivocal results exist, the presented results are partly supported by the previous findings on a sample of male basketball professional players who competed in the highest national league (Kais & Raudsepp, 2005) but not with all (Jones, et al., 1990). Due to our sample including only female players, a possible explanation for deliberative perceptions of anxiety symptoms can be found in empirical evidence (Thanopoulos & Platanou 2016) that female athletes perceive anxiety as more negative than males. The associations between intensity and directionality scales are low, except between the intensity of cognitive anxiety and directional interpretation self-confidence (negative association, moderate intensity), and between self-confidence intensity and directional interpretation of self-confidence (positive association, moderate intensity). This means that facilitative interpretation of self-confidence has a protective potential for experiencing cognitive anxiety, and secondly, that the more self-confident players are, the more they would interpret self-confidence as facilitative (and opposite). These results are partially supported by a previous study (Edwards & Hardy, 1996).

In this study, the results directly associated with the main research aims are addressed to investigate the anxiety-pre-performance expectations and anxiety-performance relationship. Considering the direction and strength of the association between different subjective performance measures: Expectation of good performance, Expectation of winning, and Expectation of a hard match, a positive relationship can be seen, of moderate intensity. Statistically, it means that these expectations share some common variance, but also they have some unique variances. From a practical standpoint, it would mean that athletes who pose a higher expectation of a good performance, to some extent, tend to posit a higher expectation of winning and a hard match. However, the regression analysis revealed that the only significant negative predictor of Cognitive anxiety and Somatic anxiety intensity is Expectation of a good performance. Moreover, the same expectation positively predicts the intensity as well as directional interpretation of self-confidence. The results obtained suggest that athletes with higher Expectation of a good performance would experience a lower degree of cognitive and somatic anxiety and a higher degree of self-confidence and also a more facilitative perception of self-confidence. Additionally, other results that add complexity to these relationships are that Expectation of a good performance is less prominent when compared to Expectation of winning and with Expectation of a hard match. At first sight, the results obtained seem to be unexpected and contrary to Martens' theoretical assumptions (Martens, et al., 1990) that higher performance expectations are related to higher cognitive anxiety and lower self-confidence. A possible partial explanation can be found in Jones's control model of competition anxiety and in the different types of competition goals (Jones, & Hanton, 1996). In the heart of Jones's model are behaviour toward specific goals, expectation of goal attainment, and degree of (perceived) control over goal attainment. Different types of goals differ from each other according to the degree of controllability. Performance goals are focused on the specific, desired standard of performance, whereas outcome goals are focused on the outcome or result of a competitive event and include comparison with other athletes. Performance goals in comparison to the outcome goals are more under personal control. In other words, and in accordance with propositions of Jones's model, we can assume that Expectation of good performance emerged as a negative predictor of both components of the anxiety intensity and positive of self-confidence intensity and also an interpretation of self-confidence thanks to its potential to refocus athlete's attention from less to more controllable factors. Unlike individual sports, where individual performance is under the personal control of an athlete, basketball is a team sport and the outcome depends on the performance of each individual player, as well as their cooperation and cohesiveness. Additionally, Expectances of winning depend on the performance of the opposite team. Bearing in the mind that our sample consisted of experienced and successful players, we can assume that in the light of the above-mentioned characteristics of team sport, they adopted more comprehensive and more adaptive criteria for setting expectations and learned to successfully cope with factors that are less or not under their control (do not focus on the expectation of winning and having a hard match). Due to these reasons, Expectation of winning and Expectation of a hard match probably did not emerge as significant predictors of anxiety intensity.

In the current study, the intensity of cognitive anxiety and intensity of somatic anxiety are in negative correlation with Satisfaction with one's own performance and Fulfilment of perceived goals set by the coach. Additionally, only the intensity of cognitive anxiety is negatively associated with Coach's assessment of athletes' performance. Although there are moderately positive correlations among all three performance measures, the regression analysis revealed only one significant prediction: Satisfaction with performance is predicted by intensity of cognitive anxiety (negative predictor). It means that athletes who scored higher on cognitive anxiety concurrently are less satisfied with their own performance (and opposite). These results are generally supported by a previous study of a sample of swimmers (Polman, et al., 2007), but not in detail, which showed no significant relationship between anxiety and different measures of performance, including satisfaction with one's own performance. On the other hand, completely different expectations could be formed based on Craft's and collaborators' meta-analyses (2003). It could be expected that self-confidence appears as a better predictor of performance than anxiety. Further, our results indicated a relatively weak anxiety-performance relationship, congruent with the results of Craft's meta-analysis (Craft at al., 2003). In sum, with the existence of numerous performance measures (objective and subjective), but none universally reliable, any further precise comparison with previous results could be classified as complicated and problematic.

4. CONCLUSION

This study is one of few aimed to explore specific expectancy antecedents of anxiety on a sample of successful female basketball players. The presented results indicated that Expectation of a good performance is the only significant predictor of all three components of multidimensional components of anxiety as well as directional interpretation of self-confidence. Also, this study aimed at extending empirical findings about the complex relationship between anxiety and performance. Although moderate positive correlations between different measures of subjective self-assessment of performance and coaches' assessment of individual performance have been shown, only intensity cognitive anxiety emerged as a significant predictor of performance satisfaction.

Results of the current study potentially have two important implications for the practice of sports psychology and could be implemented in interventional programs for preventing and reducing the precompetitive anxiety state. First, our results suggest a potentially protective role of facilitative interpretation of self-confidence for experiencing cognitive anxiety. In other words, the promotion of facilitative perception of self-confidence can be recommended. The next contribution is based on the assumption about the possible anxiety protective effects of dominating Expectation of a good performance. It can be recommended to athletes to systematically develop and encourage expectation of a good performance along with setting performance goals.

The study has some limitations that give perspectives for future research. The first one is methodological in nature and refers to the relatively small number of participants. The participants in this study were highly selected female basketball players, and there is not much possibility of including a larger number of female basketball players who compete at the same level in our country. Consequently, having in mind that some antecedents of competitive anxiety are universal, while some are specific and unique for a concrete sport discipline, the findings cannot be highly generalized, but only for team sports. Future research could include different antecedents of anxiety as well as different moderators like gender, different ages, less and more experienced athletes, different competition levels, and also athletes from other sports. The results about the anxiety-performance relationship did not achieve further advances in its comprehensive understanding. From the methodological point of view, examining and developing more reliable measures of performance would be valuable.

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ODNOS IZMEĐU INTENZITETA I ANKSIOZNOSTI I OČEKIVANJA PRE TAKMIČENJA I TAKMIČARSKOG USPEHA

*Tokom sportskih takmičenja sportisti doživljavaju anksioznost, često intenzivnu, koja može uticati na performanse i dobrobit. Prvi cilj ove studije bio je da se testira prediktivna moć očekivanja pre nastupa za intenzitet i smer višedimenzionalnih komponenti anksioznosti stanja. Drugi cilj je bio da se testira prediktivna moć direktnih i interaktivnih efekata intenziteta i smera simptoma anksioznosti na performanse. Uzorak su činile košarkašice (N= 58) prosečne starosti M=15,68±,99 i prosečnog sportskog iskustva M=5,85±2,23, tokom finalnog turnira. U roku od sat vremena pre meča završili su CSAI-2, CSAI-2-d, tri pojedinačne stavke o očekivanjima učinka i četiri pojedinačne stavke koje se odnose na procenu učinka. Nakon meča, igrači su odgovarali na tri pojedinačna pitanja za procenu učinka. Posle utakmice treneri timova (n=5) su takođe ocenjivali učinak pojedinačnih igrača. Regresiona analiza je otkrila da se očekivanje dobrog učinka pojavilo kao jedini negativni prediktor Intenziteta kognitivne anksioznosti, Intenziteta somatske anksioznosti i pozitivni prediktor Intenziteta i smera interpretacije samopouzdanja. Samo je Intenzitet kognitivne anksioznosti negativan prediktor zadovoljstva učinkom. Dobijeni rezultati upućuju na zaključak da se dominacija Očekivanja dobrog učinka može posmatrati kao zaštitni faktor koji ima potencijal da umanji anksioznost i poveća samopouzdanje i percipira samopouzdanje kao podsticajnije za učinak. Ostala testirana predviđanja mera anksioznog učinka nisu značajna. Potrebno je više studija da bi se istražili drugi potencijalni prethodnici i moderatori komponenti anksioznosti. Takođe, dalji empirijski razvoj mera performansi i testiranje odnosa anksioznosti i učinka bi unapredili sveobuhvatno razumevanje tako složenih odnosa*Ključne reči: *izvođenje, očekivanja vezana za izvođenje, posttakmičarske mere izvođenja, intenzitet stanja anksioznosti, interpretacija delovanja anksioznosti.*

Ključne reči: *performansa, očekivanja pre takmičenja, intenzitet anksioznosti, interpretacija pravca anksioznosti*

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Research article

EFFECTS OF BALL PILATES ON MUSCULAR FITNESS IN FEMALE ADOLESCENTS

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Abstract. *This study determined the effects of ten-week Pilates ball training on muscular fitness in female adolescents. The sample of 48 participants was randomly divided into the experimental (n = 24) and control group (n = 24). The experimental group (age: 15.28 ± 0.48; body height: 164.47 ± 4.59 cm; body weight: 58.72 ± 6.68 kg) performed the Pilates ball program in physical education classes twice a week for ten weeks, while the control group (age: 15.26 ± 0.29, body height: 164.35 ± 4.75 cm; body weight: 58.86 ± 5.99 kg) performed the standard physical education program. Muscular fitness was assessed by flexors, extensors and lateral torso muscles endurance tests, the front plank test, and the single-leg squat test. The results showed that both groups of participants statistically significantly improved muscular fitness between the two measurements (p < 0.01), but numerically greater effects were achieved in the experimental group. The most remarkable effects between the two measurements of the experimental group were registered in the torso flexor and extensor endurance. In the control group, the most significant effects were found in bilateral torso endurance. In addition, significantly greater effects (p <0.01) at the final measurement were determined in the experimental group for the endurance of torso flexors (p <.01) and extensors (p <.05) and in the single-leg squat test when performed with the right leg (p <.01). In bilateral torso endurance assessment tests, more significant effects were registered only at a numerical level in the experimental group. The authors concluded that exercising on an unstable compared to a stable surface is a more efficient training stimulus in transforming torso flexor and extensor muscles and dynamic control of hips and legs.*

Key words: *students, training on unstable surfaces, physical education, torso stabilizers*

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INTRODUCTION

Trunk stabilizer muscle training is increasingly prevalent in practice, considering its numerous benefits in conditioning and physiotherapy. The central body region consists of muscles that support and stabilise the lumbopelvic complex and kinetic chain, and control movement during the production and transfer of force while performing functional movements (Skotnicka, Karpowicz, Sylwia-Bartkowiak, & Strzelczy, 2017). Stabilising the trunk, these muscles significantly affect motor behaviour and efficiency.

According to Willson, Dougherty, Ireland, & Mcclay (2005) stability can be achieved only by the coordinated action of active (muscles), passive (spinal column), and control systems (nervous system). The active system consists of global and local torso muscles, with the former transferring the force and moving the spinal column as a whole. In contrast, local muscles, which are smaller and positioned deeper, cannot produce large force but are significant in proprioception, postural control, and spinal column stability (McGill, 2001). Their development should be planned in the initial stages of torso stability and mobility training in such a way as to maintain the correct position of the spine column during exercise (Cartel, Beam, McMahan, Barr, & Brown, 2006). The harmonious development of all torso stabilizers is essential as disproportion in their development leads to compensatory movements and imbalances in the global chain of stability (Perić, Stojanović, Pavlović-Veselinović, Ilić, & Stojanović, 2015).

Stability is necessary for the performance of functional movements in everyday life, sports and recreation. Increasing stability improves movement and physical fitness and, thus, performance in sports as it enables complete transfer of force from the lower to the upper extremities, and in the opposite direction (Cosio-Lima, Reynolds, Winter, Paolone, & Jones, 2003; Prieske et al., 2016; Sukalinggam, Sukalinggam, Kasim, & Yusof, 2012).

The core muscles are composed of deep, slow muscle fibers that make up the local muscular system and superficial, fast muscle fibers that make up the global muscular system. Deep muscles control and limit excessive pressure forces and rotational forces between the vertebrae and increase intra-abdominal pressure and spinal rigidity to improve intervertebral neuromuscular control. Superficial muscles transfer the load between the upper and lower extremities, provide stability between the pelvis and the spine, and ensure body center stabilization and eccentric control during functional movements (Clark, Lucett, McGill, Montel, & Sutton, 2018).

Scientific literature is dominated by research monitoring the effectiveness of torso stability training on electromyographic activity (EMG), strength, and endurance of the global trunk stabilizers. In contrast, local stabilizers have been studied considerably less. Research indicates that torso stabilizers develop more efficiently, especially in non-athletes, by exercising on an unstable than a stable surface due to increased proprioceptive demands (Carter et al., 2006; McCackey, 2011; Prieske et al., 2016; Sekendiz, Cug, & Korkusuz, 2010; Stanton, Reaburn, & Humphries, 2004; Sukalinggam et al., 2012).

Although there are contradictory findings (Anderson & Behm, 2004), it has been determined that an unstable surface is an additional stimulant that significantly increases EMG activity (Behm, Leonard, Young, Bonsey, & MacKinnon, 2005; Duncan, 2009; Kim, Kim, & Chung, 2014; Lehman, Hoda, & Oliver, 2005; Ostrowski, Carlson, Lawrence, 2017; Petrofski et al., 2007; Vilaca-Alves et al., 2016), so training on a Pilates ball is recommended for improving torso stability. However, some research suggests that EMG activity does not depend on the stability of exercising surfaces (Pirauá et al., 2017; Uribe et al., 2010).

Although the application of props (dumbbells, medicine balls, smaller balls, etc.), as an additional load to unstable surface exercise, can reduce the EMG activity, additional load has been found to generally increase the efficiency of exercise in a dynamic regime without violating the movement pattern (Anderson & Behm, 2004; Baechle & Earle, 1994).

In a number of studies, training on a Pilates ball is implemented along with some other training, primarily technical and tactical, cardiovascular, or load training. Research points to a large diversity in the selection and dosage of training variables. Still, it has generally been determined that the period of 6 to 12 months with a frequency of two to three training sessions a week is sufficient to provoke adaptive changes of torso stabilizer muscles, assuming that the other training variables are optimally dosed. The degree of adaptation primarily depends on the initial fitness of athletes, selection of exercises, frequency and intensity of the training sessions, the length of the recovery phases, and the total duration of the experiment.

The authors have mainly compared the effectiveness of anterior, posterior, and lateral planks on unstable (standard or mini Pilates ball) and stable surfaces (ground or bench) on the strength and endurance of torso stabilizer muscles. They have generally confirmed the superiority of exercise on an unstable compared to a stable surface (McCackey, 2011; Prieske et al., 2016; Sukalinggam et al., 2012). However, a considerably smaller number of studies have found that trunk stability can also be effectively improved by a dynamic regime of exercise using only torso flexion and torso extension exercises on a ball without any endurance exercises.

Despite a large number of studies, the effectiveness of progressive Pilates ball training, programmed by exercises performed in the static and dynamic regime of exercise, has still been insufficiently studied, especially in females without previous training experience. Therefore, this study was based on the assumption that by combining different exercise regimes on an unstable surface that provokes greater muscular activity due to increased postural stability requirements, torso stabilizer endurance would be significantly improved. Furthermore, stronger torso stabilizers would enable a more comprehensive transfer of force to the upper and lower extremities, which would improve sports performance. For these reasons, this longitudinal research determined the effectiveness of a Pilates ball on muscular fitness in young female adolescents.

METHOD

The sample of participants

The study involved 48 first-year students of the "Svetozar Marković" Grammar School in Niš, with an average age of 15.28 ± 0.48 years. All participants included in the experiment were clinically healthy and without previous training experience in sports clubs for the last six months. The only form of organized exercise in which they were involved was regular physical education teaching. The participants were first thoroughly informed about the experimental research goal and concept in written form. Then, if they were interested in participating in the research, they submitted written consent to be included in the research signed by their parents. Parental consent was necessary since the participants were underage. Finally, the participants were told that they could withdraw from the research at any time if they wanted to, for any reason.

The research ensured the anonymity of the participants following the recommendations for clinical research defined by the World Medical Association's Declaration of Helsinki (2013). Statistical data processing included the testing results of only those participants who had fewer than two absences during the experimental period.

The sample of participants was randomly divided into the experimental group (EG) and control group (CG) of 24 participants in each. The basic anthropometric characteristics (average body height [cm], average body weight [kg], and body mass index [kg / m^2]) of the experimental and control group are shown in Table 1.

Table 1 Basic anthropometric characteristics of the experimental and control group of participants (mean values ± standard deviation)

Participants	N	MA	BH	BW	BMI
Experimental group	24	15.28 ± 0.48	164.48 ± 4.59	58.72 ± 6.68	21.78 ± 2.87
Control group	24	15.26 ± 0.29	164.35 ± 4.75	58.87 ± 5.99	21.84 ± 2.39

Legend: N - number of participants; MA - mean age (years); BH - mean body height; BW - mean body weight; BMI - body mass index.

The sample of measuring instruments

The characteristics of the sample were evaluated using the following parameters: body height (cm), body weight (kg), and body mass index (BMI=kg/m2). Body height was measured using the Martin anthropometer (GPM 101GmbH Switzerland) that measures with an accuracy of 0.1 cm. Measurement was performed according to the protocol of the International Biological Program - IBP (Weiner & Lourie, 1969). Body weight and the body mass index were measured using the body structure analyzer (Inbody 720 Tetrapolar; 8-Point Tactile Electrode System - Biospace Co. Ltd). Participants were told in advance not to have breakfast before the measurement.

Muscle fitness was assessed using the following tests:

1. Trunk Flexor Endurance Test
2. Trunk Extensor Endurance Test
3. Trunk Lateral Endurance Test – right side
4. Trunk Lateral Endurance Test – left side
5. The Front (Forearm) Plank Test
6. Single-Leg Squat Test – right leg
7. Single-Leg Squat Test – left leg

Tests for isometric endurance assessment of the flexors, extensors, and lateral trunk muscles were taken from the American Council on Exercise (2015) that recommends McGill's testing protocol. The reliability and validity of these tests were confirmed in the study of Evans, Kathryn, Refshaugea, and Adams (2007) and del Pozo-Cruz, Mocholi, del Pozo-Cruz, Parraca, and Adsuar (2014). In addition, the clinical single-leg squat test was taken from McGovern, Martin, Christoforetti, and Kivlan (2018), and its reliability and validity were confirmed in the study of Crossley, Zhang, Schache, Bryant, and Cowan (2011) and McGovern, Christoforetti, Martin, and Phelps (2019). The reliability and validity of the front plank test, taken from the Thompson, Gordon, Pescatello, and the American College of Sports Medicine (2010), were confirmed in the study of Tong, Wu, and Nie (2014). All the applied tests are timed tests that assess the isometric endurance of muscles. The result of all the tests except for the single-leg squat test is the time of holding the correct static position, expressed in seconds.

The trunk flexor endurance test is a timed test that assesses the muscular endurance of the rectus abdominal muscle, the transverse abdominal muscle, and the oblique abdominal muscles. The examinee sits on the floor with hips and knees bent at a 90-degree angle and shoulders leaning against a board positioned at a 60-degree incline in relation to the floor. The feet should rest on the floor (or be fastened with a belt) along the entire length, and the hips, knees and the second toe should be in line. The examinee should cross his arms over the chest so that palms touch the opposite shoulder. The goal of the test is to hold this position without back support for as long as possible. The test result is the duration of the examinee's holding the proper position, expressed in seconds.

The trunk extensor endurance test involves static, isometric contraction of the trunk extensor muscles that stabilize the spine. The examinee first lies on his stomach on a raised surface (Swedish box), positioning the iliac crest at the edge of the surface on which he lies while supporting the upper part of the body with his hands against the floor. The examiner stabilizes the examinee's legs with his hands or nylon tape. The examinee then crosses his arms over the chest and maintains a position in which the upper part of the body is without support by trunk extensor endurance muscles. The aim of the test is for the examinee to maintain a horizontal position using the strength and endurance of the trunk extensor muscles for as long as possible. When the examinee breaks the horizontal position by bending the trunk downwards, the test is terminated. The test result is the duration of the examinee's holding the proper position, expressed in seconds.

The trunk lateral endurance test assesses the endurance of transverse abdominal muscles, oblique abdominal muscles, the quadratus lumborum muscle, and spinal extensor muscles. The examinee first lies on his side with legs extended, aligning his feet on top of each other or in a tandem position (heel-to-toe), leaning against the floor with forearm bent at the elbow and on the sides of his feet. The upper arm should be extended along the side of the body or across the thorax to the opposite shoulder. The hips should be elevated off the floor, and the body should be in straight alignment (head, neck, trunk, hips, and legs). The goal of the test is to hold this position for as long as possible. The result in this test is the endurance time in the lateral bridge, expressed in seconds. When the examinee breaks the position, the test is terminated. Considering that the test is bilateral, the endurance time in a proper position is measured on both the left and right side of the body.

The single-leg squat test is a functional test for the hips and lower legs, containing balance, mobility, and strength elements. It is deemed that the quality of performing this test reflects neuromuscular control during walking. Hip abduction during walking can be observed in persons who underperform in this test (Alexander, Crossley, & Schache, 2009). The test is used to assess lower body strength, particularly the hip flexor and knee extensor, gluteal muscle groups, and hip stabilizers. The examinee should first stand on one leg while the other leg is lifted off the ground in front of the body so that the hip is flexed to approximately 45° and the knee of the non-stance leg flexed to approximately 90°. The arms should be extended in front of the body freely or with hands clasped. From this position, the examinee should squat down so that the flexion in the knee joint is approximately 60° and then return to the starting position. Clinical observation usually involves knee and hip stability assessment. During the test, the knees, feet, and hips should remain in line. The examinee should perform five successive repetitions on each leg, where each squat is worth 15 points with a maximum score of 75 points. In the case of compensatory movements (torso rotation, turning the hips inwards or outwards, or the movements of the knee inwards), the test is interrupted.

The front plank test evaluates the endurance of the trunk stabilizer muscles, especially the endurance of the stabilizers of the back of the trunk that keep the spine in neutral alignment during this test. The test is performed so that the examinee lies down on his stomach and assumes the front plank position leaning against the floor only by his forearms and toes. In doing so, the hips should be at shoulders level, and elbows bent at an angle of 90° and positioned directly below the shoulders. In addition, the body should be fully extended from the shoulders to the heel without raising or lowering the hips beyond shoulder level. The test result is the examinee's holding time in the correct position, expressed in seconds.

Procedures

The research was conducted in the "Svetozar Markovic" Grammar School in Niš in the second semester of the 2018/2019 school year. The experimental program of the Pilates ball lasted for ten weeks and was carried out in physical education classes, twice a week for 45 minutes (a total of 20 classes). The classes had a standard, four-part structure that included introductory, preparatory, main, and final parts (Table 2).

Before the beginning and at the end of the experimental period, appropriate initial and final measurements of parameters for assessing the sample characteristics and muscle fitness tests were performed to determine the variability of the results from the initial to the final condition in the experimental and control groups. The parameters for assessing the sample characteristics were measured on the first day of measurement in the appropriate premises of the Faculty of Sports and Physical Education in Niš. On the second and third day of measurement, the muscular fitness variables were measured in the gym of the "Svetozar Marković" Grammar School in Niš.

Measurements were taken by previously trained measurers, PhD students of the Faculty of Sport and Physical Education, and Physical Education teachers. All the measurers received instructions for measurement and testing in advance. The same group of measurers conducted both the initial and final measurements at approximately the same time of day and with the same measuring instruments according to standardized measurement protocols. During the measurement, the participants were barefoot and minimally dressed. Testing was conducted under identical conditions for all participants. After the initial measurement, the participants were randomly divided into an experimental and a control group.

The contents of the introductory, preparatory and final phases of the physical education classes were the same for both groups (Table 2). In the introductory phase of the class (3-5 minutes), simple and familiar movements with an already formed dynamic stereotype were applied to ensure the dynamics of exercise and thus the necessary physiological impact on the body. The means of the introductory part of the class were "natural forms of movement" (walking, brisk walking, running, jumping, etc.), various figures and other stylistic movements, and various elementary games, which enabled the physiological warm up of the student's body with their dynamic content. In the preparatory phase of the class (8 minutes), complexes of shaping exercises in pairs and with props (with a hoop, ball, and jump rope) were performed, with the aim of a complete preparation of the muscles, tendons, and ligaments for the upcoming activities in the main phase of the class. In the main phase, which lasted for 30 minutes, the experimental group carried out the experimental program of Pilates ball exercises for trunk muscle stabilizer development. In contrast, the control group followed the physical education curriculum contents prescribed by the Institute for the Advancement of Education and Upbringing. In the final phase of the class (3-4 minutes), both groups of participants did stretching exercises.

Table 2 The structure and content of the classes of the experimental and control program

Phase of the class	Experimental group	Control group
Introductory	Physiological warming (3-5 min)	Physiological warming (3-5 min)
Preparatory	Shaping exercises (8-10 min)	Shaping exercises (8-10 min)
Main	Pilates on the ball (25-30 min)	Volleyball, athletics and gymnastics program (25-30 min)
Final	Static stretching exercises (5 min)	Static stretching exercises (5 min)

The experimental Pilates ball program was designed according to the guidelines of Clark et al. (2018). By optimal development of neuromuscular efficiency and gradual increasing of proprioceptive requirements during the training period, the necessary conditions for efficient development of muscle stability of the global and local stabilization system were created. In the basic phase of neural adaptation, which lasted for three weeks, the emphasis was on performing the basic movements necessary for establishing motor control and getting used to an unstable exercise surface. During three weeks, participants performed exercises to develop static stability of the body core front, side, and back, and the flexion, extension, and trunk rotation exercises necessary to improve the functional training outcomes. The movements were one-dimensional and performed with minimal spinal column and pelvis movement to improve neuromuscular efficiency and intervertebral stability. The emphasis was more on the quality than quantity of the exercises, so the exercises were done at a slow pace. During exercise, the participants tried to maintain stability and optimal neuromuscular control which enables coordinated movement.

In the developmental phase of accumulation characterized by increased neural requirements, the participants did significantly more complex and more intensive exercises for improving core muscle dynamic stability (trunk core stabilization during limb movements) and lateral and rotational flexion and trunk extension exercises to improve muscle strength and balance. The spinal column eccentric and concentric movements were done more dynamically and with a full range of motion.

The last, advanced phase of specialization was characterized by structurally more complex and energetically more demanding multi-dimensional movements that include a larger number of components in one movement. It was conducted to increase force production of the trunk stabilizer muscles for the sake of improving dynamic core stability. Trunk lateral and rotational flexion and extension exercises were done faster than the exercises in the previous phase, but not too fast so that the coordination of movements would not be disturbed.

Exercise progression is achieved by reducing the support surface, increasing proprioceptive requirements, changing the number of repetitions and sets, and, in the case of time-limited exercises, increasing exercise time. Furthermore, the applied exercises evenly engaged the front and back muscle groups of the body, which enabled the harmonious development of the muscles and prevented injuries due to possible imbalances. Along with the improvement of neuromuscular coordination and stability of the spinal column and lumbopelvic region, the participants also improved functional efficiency, so they performed the functional movement patterns without excessive spinal movements during flexion, extension, lateral flexion, and trunk rotation exercises.

Table 3 Experimental program

Phase 1 / Week 1 /Pace: Slow				Phase 1 / Week 2 /Pace: Slow			
Exercises	S	REP	Time (s)	Exercises	S	REP	Time (s)
Balanced Sitting – one leg up	1	/	:60 el	Balanced Sitting – one leg up	1	/	:60 el
Ball Prone Bridge	1	/	:60	Ball Prone Bridge	2	/	:45
Ball Side Bridge	1 es	/	:45 es	Ball Side Bridge	2 es	/	:30 es
Ball Supine Bridge	1	/	:60	Ball Supine Bridge	2	/	:45
Ball Crunch	3	8	/	Ball Crunch	3	8-10	/
Ball Trunk Hyperextension	3	8	/	Ball Trunk Hyperextension	3	8-10	/
Ball Trunk Rotation	1	8 es	/	Ball Trunk Rotation	1	8-10 es	/
Phase 1 / Week 3/Pace: Slow				Phase 2/ Week 4/Pace: Medium			
Exercises	S	REP	Time (s)	Exercises	S	REP	Time (s)
Balanced Sitting – one leg up	1	/	:60 el	Kneeling on a Ball -4F	1	/	:15
Kneeling on a Ball -4F	1	/	10	Plank - forearms on ball	1	/	:20
Ball Prone Bridge	2	/	:60	Ball Side Bridge - upper leg up	2 es	/	:35 es
Ball Side Bridge	2 es	/	:35 es	Ball Supine Bridge- one leg up	1	/	:35 el
Ball Supine Bridge	2	/	:60	Ball V-Pass	2	10	/
Ball Crunch	3	10	/	Ball Diagonal Crunch	2	8 es	/
Leg Raise – ball between feet	1	10	/	Ball Side Crunch	2	8 es	/
Ball Trunk Hyperextension	3	10	/	Ball Trunk Hyperextension	2	10	/
Ball Trunk Rotation	1	10 es	/	Ball Reverse Hyperextension	1	12	
/	/	/	/	Ball Hips Rotation	1	10 es	/
Phase 2 Week 5 /Pace: Medium				Phase 2 Week 6 /Pace: Medium			
Exercises	S	REP	Time (s)	Exercises	S	REP	Time (s)
Kneeling on a Ball -4F	1	/	:15-20	Kneeling on a Ball -4F	1	/	:20
Plank - forearms on ball	1	/	:25	Plank - forearms on ball	1	/	:30
Ball Side Bridge - upper leg up	2 es	/	:40 es	Ball Side Bridge - upper leg up	2 es	/	:45es
Ball Supine Bridge - one leg up	1	/	:40 el	Ball Supine Bridge - one leg up	1	/	:50 el
Ball V-Pass	2	10-12	/	Ball V-Pass	2	12	/
Ball Diagonal Crunch	2	8-10 es	/	Ball Diagonal Crunch	2	10 es	/
Ball Side Crunch	2	8-10 es	/	Ball Side Crunch	2	10 es	/
Ball Trunk Hyperextension	2	10-12	/	Ball Trunk Hyperextension	2	10	/
Ball Reverse Hyperextension	1	12-15	/	Ball Reverse Hyperextension	2	10	/
Ball Hip Rotation	1	12 es	/	Ball Hip Rotation	2	8 es	/
Phase 2/ Week 7/Pace: Medium				Phase 3 / Week 8 /Pace: As fast as can be controlled			
Exercises	S	REP	Time (s)	Exercises	S	REP	Time (s)
Kneeling on a Ball -4F	1	/	:25	Kneeling on a Ball -2F	1	/	:15
Ball Forearm Plank	2	/	:17	Ball Forearm Plank	2	/	:20
Ball Side Bridge - upper leg up	2 es		:50 es	Ball Side Bridge - upper leg up	2 es	/	:55 es
Ball Supine Bridge - one leg up	1	/	:55/:60 el	Ball Supine Bridge - one leg up	2	/	:60 el
Ball V-Pass	2	12-15	/	Ball V-Pass	3	12	/
Ball Diagonal Crunch	3	8 es	/	Pike on the ball	1	8	/
Ball Side Crunch	8	8 es	/	Ball Diagonal Crunch	3	8-10 es	/
Ball Trunk Hyperextension	2	10-12	/	Ball Side Crunch	3	8-10 es	/
Ball Reverse Hyperextension	2	10-12	/	Supermen on a Ball	3	10-12	/
Ball Hip Rotation	2	10 es	/	Ball Hip Rotation	3	8 es	/
Phase 3 / Week 9 /Pace: As fast as can be controlled				Phase 3/ Week 10 /Pace: As fast as can be controlled			
Exercises	S	REP	Time (s)	Exercises	S	REP	Time (s)
Kneeling on a Ball -2F	1	/	:20	Kneeling on a Ball -2F	1	/	:25
Ball Forearm Plank	2	/	:25	Ball Forearm Plank	2	/	:30
Ball Side Bridge - upper leg up	2 es	/	:60 es	Ball Side Bridge - upper leg up	3 es	/	:45 es
Ball Supine Bridge - one leg up	3	/	:45 el	Ball Supine Bridge - one leg up	3	/	:50 el
Ball V-Pass	3	12-15	/	Ball V-Pass	3	15	/
Pike	2	8	/	Pike	3	8	/
Supermen	3	12	/	Supermen	3	15	/
Ball Hip Rotation	3	8-10 es	/	Ball Hip Rotation	3	10 es	/
Ball Diagonal Crunch	3	10 es	/	Ball Diagonal Crunch	3	10-12 es	/
Ball Side Crunch	3	10 es	/	Ball Side Crunch	3	10-12 es	/

Legend: el - with each leg; es - on both sides; 4F - four points of support;
2F - two points of support; REP - the number of repetitions; S -the number of sets.

The participants of the control group chose volleyball as a sports game of the students' choice (Table 4).

Table 4 Control group program

Week	Class	Teaching units
I	1.	Volleyball: bouncing the ball with fingers and a spike in a jump and with a change of direction
	2.	Volleyball: side "fleet" serve (swinging serve) and reception serve
II	3.	Volleyball: "jump fleet" serve (jump fleet) and serve reception
	4.	Volleyball: spiking and blocking the ball (double and triple block: blocks of two and three students)
III	5.	Athletics: throwing a 4 kg ball, one of the rational techniques
	6.	Athletics: improvement of the short distance running technique: 100 m; relay 4 x 100 m.
III	7.	Athletics: improvement of the middle distance running technique: 800 m.
	8.	Athletics: cross country: spring: 800 m.
IV	9.	Strength exercises without and with small weights - up to 4 kg
	10.	Strength exercises without and with small weights - up to 4 kg
V	11.	Gymnastics (ground exercises): scales by bending and squatting and joining, reflecting one leg forward roll
	12.	Gymnastics (ground exercises): position on the fists, endurance, reel forward
VI	13.	Gymnastics (ground exercises): two connected star jumps to the right and left
	14.	Gymnastics (ground exercises): vault: squat on and vault with legs spread (for advanced level: amanar)
VII	15.	Gymnastics (composition on a high beam): jump, swings, turns, handstand balance, walking up with hop steps, scale, frontal and lateral dismounts
	16.	Gymnastics (composition on a high beam): jump, swings, turns, handstand balance, walking up with hop steps, scale, frontal and lateral dismounts
VIII	17.	Polygon of dexterity and agility
	18.	Polygon of dexterity and agility
IX	19.	Aerobics
	20.	Aerobics
X	21.	Exercises in corrective gymnastics
	22.	Exercises in corrective gymnastics

Methods of data processing

For all anthropometric measures and muscle fitness tests, basic descriptive parameters of measures of central tendency and variability of results at the initial and final measurement were calculated. As data collected in the research are sourced from the interval measurement scale, the following descriptive measures were calculated: arithmetic mean (Mean), minimum (Min) and maximum (Max) value of results, standard deviation (St.dev.), indicators of asymmetry (Skewness) and flatness (Kurtosis) of the results distribution, and significance of the Shapiro-Wilk normality test (Shapiro-Wilk coefficient).

The Shapiro-Wilk normality test was used following previous research findings, confirming that this test is more reliable in assessing the normality of distribution when research is conducted on small samples of participants.

Considering that the groups of participants did not differ statistically significantly in muscular fitness at the initial measurement, the Multivariate Analysis of Variance

(MANOVA) was calculated to determine multivariate differences between the experimental and control groups in muscular fitness at both the initial and final measurement. At the univariate level, intergroup differences in muscle fitness at the initial and final measurements were determined by the t-test for independent samples.

Statistical significance ($p \leq .05$) of Wilks' lambda criterion was calculated to determine a multivariant statistical significance of intergroup differences. Before conducting the MANOVA analysis, it was checked whether the following criteria (assumptions) for applying the specified statistical technique were met: multivariant normality, absence of outliers, homogeneity of variance, linearity, and multicollinearity.

The one-way repeated measures MANOVA was applied to establish differences in muscular fitness at the multivariate level within the experimental and control groups between the initial and final measurements. The differences between the two measurements within the experimental and control groups were determined by the t-test for dependent samples at the univariate level. Partial eta-squared (η^2p) was used to estimate the effect size. Effect size values are classified into several categories (Ferguson, 2009): if $0 \leq \eta2p < 0.05$ then there is no effect; if $0.05 \leq \eta2p < 0.26$ then the effect is small; if $0.26 \leq \eta2p < 0.64$ then the effect is medium; if $0.64 \leq \eta2p$ then the effect is large.

Statistical data processing was performed in the SPSS version 23.0 statistical data processing package.

RESULTS

Table 4 shows the results of the Multivariate Analysis of Variance of the muscle fitness data of the experimental and control groups at the initial measurement. The results indicate that the experimental and control group at the multivariate level did not differ statistically significantly in muscle fitness at the initial measurement ($p > 0.05$).

Table 4 Multivariate differences in muscular fitness between the experimental and control group at the initial measurement

Wilks' lambda	F	Effect-df	Error-df	p	η^2p
0.716	2.266	7	40	.053	.084

Legend: Wilks' lambda - the value of the Wilks' test coefficient for the equality of group centroids; F - the value of the F-test coefficient, which is an approximation of the Wilks' lambda value; Effect df and Error df - degrees of freedom; p - coefficient of significance of F-statistics; η^2p - partial squared eta (measure of effect size).

Multivariate differences in muscular fitness between the initial and final measurements of the experimental group, determined by the one-way repeated measures MANOVA, are shown in Table 5. The results indicated that statistically significant differences in muscular fitness ($p < 0.01$) between the initial and final measurements of the experimental group were determined and that the size of the effect was large ($\eta^2p = .990$).

Results of the t-test for dependent samples (Table 6) indicate that statistically significant differences in muscular fitness were also determined at the univariate level at repeated measurements in the experimental group ($p < 0.01$) and that a great effect size ($\eta^2p \geq 0.64$) can be observed in all muscular fitness tests. The most significant effects were determined in improving the endurance of the trunk flexor muscles ($\eta^2p = .961$) and endurance of the lateral trunk muscles on the left side ($\eta^2p = .940$).

Table 5 Multivariate differences in muscular fitness of the experimental group between the initial and final measurements

Wilks' lambda	F	Effect-df	Error-df	p	η^2p
0.010	244.549	7	17	.000**	.990

Legend: Wilks' lambda - the value of the Wilks' test coefficient for the equality of group centroids; F - the value of the F-test coefficient, which is an approximation of the Wilks' lambda value; Effect df and Error df - degrees of freedom; p - coefficient of significance of F-statistics; η^2p - partial squared eta (measure of effect size). ** - statistical significance at the level of .01.

The results of the one-way repeated measures MANOVA (Table 7) indicate that at the multivariate level between the initial and final measurements of the control group, there are statistically significant differences in muscular fitness ($p < 0.01$) and that the effect size is large ($\eta^2 p = .969$).

The results of the t-test for dependent samples (Table 8) indicate that at the univariate level between the two measurements, statistically significant changes were found in all muscular fitness variables. The average values of the results of muscular fitness tests are significantly higher at the final than at the initial measurement. The value of the partial eta squared coefficient points to large effects ($\eta^2 p \geq 0.64$) in five of the seven muscular fitness tests: 1. the trunk lateral endurance test - left side ($\eta^2 p = .907$); 2. the trunk extensor endurance test ($\eta^2 p = .797$); 3. the trunk lateral endurance test - right side ($\eta^2 p = .772$); 4. the single-leg squat test - left leg ($\eta^2 p = .689$); and 5. the trunk flexor endurance test ($\eta^2 p = .639$). Medium effect size was determined in the front plank test ($\eta^2 p = .595$) and the single-leg squat test - right leg ($\eta^2 p = .490$).

Table 6 Univariate differences in muscular fitness of the experimental group between the initial and final measurements

Variable	Measurement	M	S	t	p	η^2p
TFET	I F	98.58 136.75	19.30 23.34	-23.903	.000**	.961
TEET	I F	91.54 121.08	21.28 24.09	-17.768	.000**	.932
TLET-R	I F	52.71 66.17	15.83 16.50	-13.975	.000**	.895
TLET-L	I F	48.29 64.17	14.58 15.25	-18.969	.000**	.940
TFPT	I F	65.21 100.25	18.30 25.38	-18.170	.000**	.935
SLST-R	I F	35 63.13	17.51 13.25	-15.000	.000**	.907
SLST-L	I F	25 49.79	16.94 18.68	-7.103	.000**	.687

Legend: TFET - trunk flexor endurance; TEET - trunk extensor endurance; TLET-R - trunk lateral endurance - right side; TLET-L - trunk lateral endurance - left side; TFPT - endurance in the Front Plank Test; SLST-R - single-leg squat - right leg; SLST-L - single-leg squat- left leg; I - initial measurement; F – final measurement; M - arithmetic mean; S - standard deviation; t - value of the t-test coefficient; p - coefficient of significance of t-statistics; η^2p - partial squared eta (measure of effect size). ** - statistical significance at the level of .01.

Table 7 Multivariate differences in muscular fitness of the control group between the initial and final measurements

Wilks' lambda	F	Effect-df	Error-df	p	η^2_p
0.031	76.311	7	17	.000**	.969

Legend: Wilks' lambda - the value of the Wilks' test coefficient for the equality of group centroids; F - the value of the F-test coefficient, which is an approximation of the Wilks' lambda value; Effect df and Error df - degrees of freedom; p - coefficient of significance of F-statistics; η^2p - partial squared eta (measure of effect size). ** - statistical significance at the level of .01.

Table 8 Univariate differences in muscular fitness of the control group between the initial and final measurements

Variable	Measurement	M	S	t	p	η^2_p
TFET	I	93.63	11.30	-6.387	.000**	.639
	F	107.13	11.84			
TEET	I	94.54	16.62	-9.491	.000**	.797
	F	107.50	15.94			
TLET-R	I	53.29	10.56	-8.825	.000**	.772
	F	59.17	11.01			
TLET-L	I	50.79	9.64	-14.990	.000**	.907
	F	58.17	10.46			
TFPT	I	68.79	21.10	-7.137	.000**	.595
	F	75.42	22.01			
SLST-R	I	31.25	13.93	-5.816	.000**	.490
	F	43.75	17.08			
SLST-L	I	27.50	15.74	-4.703	.000**	.689
	F	40.00	15.74			

Legend: TFET - trunk flexor endurance; TEET - trunk extensor endurance; TLET-R - trunk lateral endurance - right side; TLET-L - trunk lateral endurance - left side; TFPT - endurance in the Front Plank Test; SLST-R - single-leg squat - right leg; SLST-L - single-leg squat- left leg; I - initial measurement; F – final measurement; M - arithmetic mean; S - standard deviation; t - value of the t-test coefficient; p - coefficient of significance of t-statistics; η^2p - partial squared eta (measure of effect size). ** - statistical significance at the level of .01.

Table 9 indicates the results of the MANOVA analysis of muscular fitness between the experimental and control group of participants at the final measurement. The results indicate that the experimental and control group at the multivariate level differed statistically significantly in muscular fitness at the final measurement (p <0.01).

The results of the t-test for independent samples at the final measurement (Table 10) indicate that statistically significant intergroup differences were determined at the univariate level in four of the seven tests for assessing muscular fitness: the trunk flexor endurance test (t = 5.545, p <.01), front plank test (ttfpt = 3.621, p <.01), single-leg squat test - right leg (t = 4.390, p <.01), and the trunk extensor endurance test (t = 2.304, p <.05).

Table 9 Multivariate differences in muscular fitness between the experimental and control group at the final measurement

Wilks' lambda	F	Effect-df	Error-df	p	η2p
0.404	8.427	7	40	.000**	.596

Legend: Wilks' lambda - the value of the Wilks' test coefficient for the equality of group centroids; F - the value of the F-test coefficient, which is an approximation of the Wilks' lambda value; Effect df and Error df - degrees of freedom; p - coefficient of significance of F-statistics; η^2p - partial squared eta (measure of effect size). ** - statistical significance at the level of .01.

Table 10 Univariate differences in muscular fitness between the experimental and control group at the final measurement

Variable	Group	M	S	t	p	η^2p
TFET	E K	136.75 107.13	23.34 11.84	5.545	$.000^{**}$	.401
TEET	E K	121.08 107.50	24.09 15.94	2.304	$.026^{*}$	.103
TLET-R	E K	66.17 59.17	16.50 11.01	1.729	.091	.061
TLET-L	E K	64.17 58.17	15.25 10.46	1.589	.119	.052
TFPT	E K	100.25 75.42	25.38 22.01	3.621	$.001^{**}$	.222
SLST-R	E K	63.13 43.75	13.25 17.08	4.390	$.000^{**}$	.295
SLST-L	E K	49.79 40.00	18.68 15.74	1.964	.056	.077

Legend: TFET - trunk flexor endurance; TEET - trunk extensor endurance; TLET-R - trunk lateral endurance - right side; TLET-L - trunk lateral endurance - left side; TFPT - endurance in the Front Plank Test; SLST-R - single-leg squat - right leg; SLST-L - single-leg squat- left leg; I - initial measurement; F – final measurement; M - arithmetic mean; S - standard deviation; t - value of the t-test coefficient; p - coefficient of significance of t-statistics; η^2p - partial squared eta (measure of effect size). ** - statistical significance at the level of .01.

Comparing the average results of the muscular fitness of the experimental and control group shows that the experimental group achieved better results than the control group at the final measurement. Data on partial eta squared indicate medium effects in the trunk flexor endurance test (η^2p = .401) and single-leg squat test - right leg (η^2p = .295), and small effects in the front plank test (η^2p = .222) and trunk extensor endurance test (η^2p = .103). In the single-leg squat test, when performed on the right leg, and trunk lateral endurance tests on both sides of the trunk, the differences determined in favor of the experimental group were only at the numerical level.

Discussion

This research determined the effectiveness of a ten-week experimental Pilates ball program, conducted in regular physical education teaching, and the standard physical education program on transformational processes of muscular fitness in adolescents. The research draft had the character of a draft with equivalent groups since the groups of participants did not differ statistically significantly in muscular fitness before the experiment.

During the experimental period, both groups of female participants statistically significantly improved muscular fitness, but larger effects were achieved in the experimental group. Based on the size of the partial eta squared coefficient between the initial and final measurements of muscular fitness of the experimental group, it is evident that it has to do with large effects of the applied experimental program at both the multivariate (η^2p = .990) and univariate level (η^2p (ttfet) = .961; η^2p (tteet) = .932; η^2p (ttlet-r) = .895; η^2p (ttlet-l) = .940; η^2p (ttfpt) = .935; η^2p (tslst-r) = .907; η^2p (tslst-l) = .687) in all muscular fitness tests. The greatest effects between the two measurements of the experimental group were registered in endurance of the trunk flexors (η^2p = .961), trunk extensors (η^2p = .932), and trunk lateral stabilizers on the left side (η^2p =

.940), while the smallest effect was found in the endurance of lateral trunk muscles on the right side (η^2p = .687). The large effects between the two measurements in the bilateral single-leg squat test suggest that exercising on an unstable surface, along with improving the endurance of the trunk stabilizers, especially the trunk extensors, also improved lower body strength and the hip stabilizer muscle strength and endurance.

A significant improvement of muscular fitness was also registered in the control group of participants between the initial and final measurement (Λ= 0.031, F(7,17) = 76.311, p < 0.01). Great effect size, though numerically a little smaller than in the experimental group, was registered at both the multivariate (η^2_p = .969) and univariate level (η^2p (ttfet) = .639; η^2p (tteet) = .797; η^2p (ttlet-r) = .772; η^2p (ttlet-l) = .907; η^2p (ttfpt) = .595; η^2p (tslst-r) = .490; η^2p (tslst-l) = .689). The standard physical education program most effectively influenced the lateral endurance muscles of the left (η^2p = .907) and right side of the trunk (η^2p = .772), while the lowest impact was registered in the front plank test (η^2p = .595).

The average muscular fitness results of both groups of participants in most tests at the initial and final measurement were within the reference values for age and gender, taken from the research done by Dejanović, Cambridge, and McGill (2014). The mean values of the results of the front Plank test in both groups were within the normative values (60-120 s) both at the initial (TFPTi = 65.21 s in the experimental group; TFPTi = 68.79 s in the control group) and the final measurement (TFPTf = 100.25 s in the experimental group; TFPTf = 75.42 s in the control group), with slightly higher numerical values registered in the control group at the initial measurement and in the experimental group at the final measurement, indicating a greater influence of the experimental program compared to the control group program. Namely, the Plank exercise, which was an integral part of the experimental group's program, and which engages the front of the body's core muscles and specifically activates the oblique abdominal muscles and lateral trunk stabilizers (Aggarwal, Kumar, & Kumar, 2010), has definitely contributed to the significant development of torso flexors. The measure of the effect size indicates a medium effect in the trunk flexor endurance test (η^2_p= .401) and the single-leg squat test – right leg (η^2_p= .295), and a lesser effect in the Plank Test (η^2_p= .222) and the trunk extensor endurance test (η^2_p= .103).

By comparison with norms for age and gender, it can be noticed that the average results of the trunk flexor and extensor endurance tests at the initial (TFETi = 98.58, TEETi = 91.54, in the experimental group; TFETi = 93.63, TEETi = 94.54, in the control group) and final measurement (TFETf = 136.75, TEETf = 121.08, in the experimental group; TFETf = 107.13; TEETf = 107.50 in the control group) were also within the reference values for girls aged 15 (TFET = 161.4 ± 78.2; TEET = 171.6 ± 62.8; in the control group) and 16 (TFET = 135.5 ± 69.8; TEET = 147.7 ± 66.3).

The same was observed in tests for assessing bilateral trunk endurance, in which, according to the mentioned authors, in both groups of participants at the initial (TLET-Ri = 52.71, TLET-Li = 48.29, in the experimental group; TLET-Ri = 53.29, TLET-Li = 50.79 in the control group) and at the final measurement (TLET-Rf = 66.17, TLET-Rf = 64.17, in the experimental group; TLET-Rf = 59.17; TLET-Rf = 59.17; TLET-Lf = 58.17 in the control group) the average value were also within the normative values for 15-year-old (TLET-R = 68.2 ± 27.4; TLET -L = 70.2 ± 31.5) and 16-year-old girls (TLET-R = 55.2 ± 29.5; TLET-L = 55.7 ± 26.4). According to Dejanovic et al. (2014), the reference values of the trunk lateral endurance test performed on the left side of the body are numerically slightly higher over the norms for test performed on the right side.

Considering the fact that, at the initial measurement, the control group had numerically better results than the experimental group in all muscular fitness tests, except in the trunk flexor endurance test and single-leg squat test when performed on the right leg, in which the experimental group of participants had numerically better results, it is evident that the Pilates ball program is generally more effective than the control group's program in the transformation of muscular fitness.

The results of this research are consistent with the results of numerous previous studies that researched the effectiveness of Pilates ball exercise on muscular fitness (Carter et al., 2006; McCackey, 2011; Prachi et al., 2019; Prieske et al., 2016; Sekendiz et al., 2010; Stanton et al., 2004; Sukalinggam et al., 2012). These results generally indicated that similar effects were achieved in participants of both genders, although numerically better results were registered in male compared to female participants (Prieske et al., 2016; Stanton et al., 2004). Stanton et al. (2004) determined significant improvements in all trunk stabilizer endurance tests in a sample of fifteen-year-old athletes who performed only 12 training sessions during the six-month experimental period. The applied exercises were of similar intensity and duration as in this study. Exercise progression during the experimental period in their study was achieved only by increasing the number of repetitions and the number of sets of exercises and not by increasing the number of exercises or intensity of the exercises.

Sekendiz (2010) found that a 12-week stabilization training on a Pilates ball with a frequency of three training sessions per week was an effective training stimulant for improving strength and endurance of trunk flexors and extensors in female non-athletes. Regarding the longer duration of the experimental period and the higher frequency of training sessions than in this study, the obtained results were expected.

Similar improvements in the trunk flexor and extensor strength and endurance in non-athlete students of both genders were found by Sukalinggam et al. (2012) after six weeks of Pilates ball training, with a frequency of three training sessions per week. Participants did only dynamic trunk flexion and extension exercises, not isometric endurance exercises representing a more intense training stimulus. More significant changes were found in female participants probably because they had poorer results at the initial measurement. A study by McCackey (2011) and Prachi et al. (2019) shows that training effects similar to those from this study can be achieved in a much shorter experimental period if the program is implemented with a high frequency. However, Cosio-Lima et al. (2003) did not find significant improvements in non-athlete female students in any stabilization endurance test ($p>0.05$) after five weeks of high-frequency training (5 times a week), but only registered significant improvements in the EMG activity of trunk flexors ($p=0.04$) and extensors ($p=0.01$). In general, more significant improvements in trunk stabilizer endurance have been observed in athletes (Carter et al., 2006; Prieske et al., 2016; Stanton et al. 2004), so it can be assumed that sports activity engages trunk stabilizers to the same or greater extent as specific exercises for its development.

On the other hand, Prieske et al. (2016), in a sample of young athletes who did training for the development of core stability two to three times a week for nine weeks, found significant effects only in strengthening the trunk extensors but not the trunk flexors, even though the training program also included specific exercises for its strengthening. Such results probably occurred because the average values of the trunk flexor results at the initial measurement were significantly better than the average values of the trunk extensors, so more intensive stimuli were needed for its development. In addition, the mentioned author found similar effects in improving the endurance of the trunk extensors in the group of participants who exercised on the ground, so the conclusion that an unstable exercise surface produces greater training effects is called into question.

Effects of the experimental program

At the final measurement, the Multivariate Analysis of Variance ($\Lambda = 0.404$, F (7,40) = 8.427, $p < 0.01$, $\eta^2_p = .596$) determined statistically significant intergroup differences at the multivariate level. The results of the t-test for independent samples have shown that groups of female participants differed statistically significantly at the univariate level, but only in four of the seven muscular fitness tests. Statistically significantly larger effects at the final measurement were found in the experimental group in the single-leg squat test performed with the right leg and all the tests for assessing body core muscular endurance except in tests for assessing lateral trunk stabilizer endurance in which higher effects were registered only at the numerical level. The level of statistical significance of intergroup differences in the trunk flexor endurance test (ttfet = 5.545, $p <.01$), plank test (ttfpt = 3.621, $p <.01$) and the single-leg squat test when performed by the right leg (tslst-r = 4.390, $p <.01$) was.01, while the determined level of intergroup differences in the trunk extensor endurance test was at the .05 level of significance (tteet = 2.304, $p <.05$). In other muscle fitness tests, numerical but not statistically significant intergroup differences were registered at the final measurement in favor of the experimental group. Compared to the control group, the experimental group achieved numerically better results in both tests for assessing trunk lateral endurance and in the single-leg squat test when performed with the left leg.

In general, a more efficient training response to exercise on an unstable surface was expected given the concept of the experimental program, which contained specific exercises for the development of torso stabilizers. In addition to dynamic exercises, the experimental program contained exercises of isometric contractions of torso stabilizer muscles in conditions of increased postural requirements for maintaining stability during exercising on an unstable surface, also activating local and deep stabilizers, in addition to global ones (Carter et al., 2006). Although training in unstable conditions produces less force, training on an unstable surface obviously provides an additional load on trunk stabilizers to maintain balance in unstable conditions, which contributes to their strengthening. Furthermore, greater adaptations of synergists and trunk stabilizer muscles in the experimental group are obviously a consequence of the unstable exercise surface that provokes a more complex interaction of passive (joints and spinal ligaments) and active (neural and muscular) subsystems that keep the intervertebral neutral zones within physiological limits.

CONCLUSION

Exercise on an unstable surface improves the neuromuscular adaptations to training stimuli, so the use of Pilates balls is often an integral part of the training process. This research determined the effectiveness of the Pilates ball on the muscular fitness of female adolescents. Comparing the effectiveness of a ten-week Pilates ball program and the standard physical education program found that both programs significantly improved participants' muscular fitness during the experimental period, with numerically greater effects recorded in all muscular fitness tests in the experimental group. Pilates on a ball most effectively influenced the endurance of torso flexors and extensors, while the most significant effect of the standard physical education program, although numerically smaller than in the experimental group, was noticed in improved bilateral torso muscular endurance. Significantly greater effects of the experimental program at the final measurement were found in the single-leg squat test when performed with the right leg and all the tests for assessing the endurance of torso stabilizer muscles, except in the tests for assessing lateral torso stabilizer endurance in which higher experimental group effects were registered only at the numerical level. Accordingly, the authors conclude that a ten-week Pilates ball program is more efficient than the standard physical education program in transforming the muscular fitness of female adolescents, so its implementation in the physical education curriculum can be recommended.

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EFEKTI PILATESA NA LOPTI NA MIŠIĆNI FITNES ADOLESCENTKINJA

Ovom studijom su utvrđivani efekti desetonedeljnog treninga na pilates lopti na mišićni fitnes adolescentkinja. Uzorak od 48 ispitanica je nasumično bio podeljen na eksperimentalnu (n = 24) i kontrolnu grupu (n = 24). Eksperimentalna grupa (uzrast: 15.28 ± 0.48; visina tela: 164.48 cm; težina tela: 69.2 ± 6.3 kg) je dva puta nedeljno tokom 10 nedelja na časovima fizičkog vaspitanja sprovodila program pilatesa na lopti dok je kontrolna grupa (uzrast: 15.28 ± 0.48; visina tela: 164.35 cm; težina tela: 58.86 kg) sprovodila standardni program fizičkog vaspitanja. Mišićni fitnes je bio procenjen testovima za procenu izdržljivosti fleksora, ekstenzora i lateralnih mišića trupa, testom prednji plank i testom čučanj na jednoj nozi. Rezultati su pokazali da su između dva merenja obe grupe ispitanica statistički značajno poboljšale mišićni fitnes (p < 0.01) ali su numerički veći efekti postignuti u eksperimentalnoj grupi. Najveći efekti između dva merenja eksperimentalne grupe registrovani su u izdržljivosti fleksora i ekstenzora trupa. U kontrolnoj grupi najveći efekti su utvrđeni u bilateralnoj izdržljivosti trupa. Značajno veći efekti (p < 0.01) na finalnom merenju utvrđeni su kod eksperimentalne grupe u izdržljivosti fleksora (p < .01) i ekstenzora trupa (p < .05) i u testu čučanj na jednoj nozi izvođenom desnom nogom (p < .01). U testovima za procenu bilateralne izdržljivosti trupa, veći efekti kod eksperimentalne grupe su registrovani samo na numeričkom nivou. Autori zaključuju da vežbanje na nestabilnoj u odnosu na stabilnu površinu predstavlja efikasniji trenažni stimulans u transformaciji mišića fleksora i ekstenzora trupa i dinamičkoj kontroli kukova i nogu.

Ključne reči: *učenici, trening na nestabilnoj površini, fizičko vaspitanje, stabilizatori trupa*

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Research article

PHYSICAL ACTIVITIES AND BODY IMAGES OF THE WORKING POPULATION

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Abstract. *The aim of the research was to determine the influence of physical activity on the body image of the working population. The population from which the sample of respondents was defined consisted of the working active population, with an average age of 44 years. The total sample consisted of 500 respondents, of which 193 men and 307 women. Physical activity was determined using the IPAQ short-form questionnaire, and the level of physical activity in three domains: high-intensity physical activity, moderate-intensity physical activity, and low-intensity physical activity. To assess Body image, a Physical Appearance Scale was used which consisted of four questions to be answered in relation to four figures, using a scale ranging from 1.8 to 5.2. Based on the obtained results, it was found that there is a statistically significant effect of physical activity on the body image, namely on body dissatisfaction at the level of significance of .01 (Sig = .009), on comparative dissatisfaction with the body at the level of significance of .01 (Sig = .000), and dissatisfaction with the sexual body at the level of significance of .05 (Sig = .011) for the total sample. The individual influence of the level of physical activity in relation to gender was determined in working men on the domain of comparative dissatisfaction with the body (Sig = .032) and on the index of dissatisfaction with the body (Sig = .026). The authors conclude that the level of physical activity significantly affects the body image, and indicate the importance of engaging in physical activity in order to improve body image, especially in working men.*

Key words: *physical activity, body image, working active population*

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INTRODUCTION

Physical activity represents every movement of the body that is realized by the musculoskeletal system, the consequence of which is reflected in the energy consumption above the threshold which the body consumes at rest (Caspersen, Powel, & Christenson, 1985; Sharkey & Gaskill, 2008). As the content of free time it represents an important driver that is reflected on the autonomy and existence of man, as the basis for individual identity associated with lifestyle (Perasović, 2009). Many countries include regular physical activity in their development strategy, as a key form of preservation of human health, as well as their own body appearance. (Perić et all., 2016). Low levels of physical activity can contribute to the development of various chronic diseases and disorders (Blair, La Monte, & Nichaman, 2004). Regular physical activity affects fitness abilities, body composition, mental characteristics, anxiety, and depression, which affect the mood of each person (Pearson & Craig, 2013). According to research done by Sharkey and Gaskill (2008), physical inactivity increases the risk of developing hypertension by 35%, and people who are in poor physical shape or condition are known to have a 52% higher risk of this disease than people who are in good physical shape (Sharkey & Gaskill, 2008).

Physical activity can also improve mood, self-esteem, body appearance, and boost energy (Forrest & Stuhldreher, 2007). Because dissatisfaction with physical appearance can cause serious health problems such as depression, obesity, and eating disorders (Stice, 2002), the study found that positive associations between physical activity and satisfaction with physical appearance can increase physical activity levels. In that way, it can contribute to a more positive perception of physical appearance, which can indirectly affect better health. In addition, it has been proven that there is a positive association between happiness and life satisfaction with physical fitness, and caring for body weight as components of the perception of physical appearance (Stokes & Frederick-Recascino, 2003).

Body Image refers to the image that an individual forms according to his own body, which is an objective knowledge and subjective assessment of the characteristics of his own body. It consists of appearance, body shape, physical strength, health, and other dimensions. The degree of self-awareness affects emotions and health behaviors, such as weight control, personal social adaptations, psychological stress, self-development, and interpersonal relationships (Wang, Xie, Chen, & Lei , 2017). The more positive the body image, the more physically active a person is found to be, and vice versa, those who are dissatisfied with their body, more precisely with their own body image, have an inhibitory effect on exercise behavior and physical activity itself (Hu, 2017). It has been determined that people who are more physically active are characterized by a more positive body image than people who are physically inactive (Campbell & Hausenblas, 2009). Martin-Albo, Núñez, Domínguez, León, and Tomás (2012) conducted a sample survey of women exercising for 45–120 minutes at least twice a week in a fitness center. People who regularly participated in physical activities had a high level of respect, despite lower levels of satisfaction with their body image due to overweight. Research done by Abbott and Barber (2011) showed that women who are involved in sports activities have a higher level of body image compared to women who are not involved in some form of sports activities. The interrelationship between the two studies confirmed positive links between physical activity and body image (Contreras, Fernández, García, Palou, & Ponseti, 2010; Telleria-Aramburu, Sánchez, Ansotegui, Rocandio, & Arroyo-Izaga, 2015). Research conducted by Burgess, Grogan, and Burwitz (2006) concluded that the participation of women and men in physical activities improved physical self-perception and the relationship with their own body. The results indicated much more positive physical self-assessment pictures and significantly higher physical self-esteem of women who initially showed a low level of acceptance of their own body. Physical activity had a positive effect on self-perception, but its effect was not long-lasting (Burgess, Grogan, & Burwitz, 2006). According to research conducted by Sides-Moore and Tochkov (2011), a higher level of physical activity is indirectly associated with a better body image, and a lower urge to exercise. Physical activity is associated with upper quartile depression. Body image, both positive and negative, is an important factor, which plays a role in determining exercise habits (Sicilia, 2016). This often leads to many individuals using exercise as a method to achieve modern standards of beauty (Goudarzian, Beik, Zamani, Gorji, & Ranjbar, 2016). The difference between a positive and a negative body image may not seem like it, but it can significantly affect behavior and have a big impact on exercise habits and overall well-being (Litrell, 2017).

Working men and women differ significantly in body dissatisfaction, with women reporting higher levels of dissatisfaction. Generally speaking, men with insufficient body weight and normal weight want to be heavier, while those with excess weight want to be thinner; unlike them, women would like to be thinner, even when they are of normal weight (Van et all., 2007). Dissatisfaction with body image is strictly related to the physical activity of the body of both men and working women, more precisely, physical activity supports their better body image (Wardle, 2005). Constant storytelling and appealing to people about the relationship between body image and type of exercise can help create a more positive exercise environment for people of all levels of physical fitness, with different interests and different goals (Litrell, 2017).

The aim of the research is to determine the influence of physical activities on the body image of working men and women.

METHOD

Sample of participants

The population from which the sample of respondents was defined consisted of the working active population, with an average age of 44 years. The youngest respondent was 23 years old, and the oldest was 65 years old. The total sample consisted of 500 respondents (men = 193; women = 307). To be included in the study, the criterion was that participants had not physical disability, severe physical illness (e.g. diabetes, myocardial infarction, stroke, etc.) or mental illness.

The sample of measuring instruments

The level of physical activity was determined using the International Physical Activity Questionnaire (IPAQ, 2007). A short version was used, which has seven questions. Based on the data obtained by the questionnaire, three domains were calculated for, physical activity (Vigorous physical activity, Moderate physical activity and Low physical activity). For Body image assessment, the Physical Appearance Assessment Scale (BIDA) was used (Segura-Garcia, Papaianni, Rizza, Flora, & De Fasio, 2012). The scale consists of four domains (Dissatisfaction with the body, Sexual Dissatisfaction, Comparative Body Dissatisfaction, and the Body Dissatisfaction Index). The applied questionnaires have satisfactory metric characteristics for the stated sample (Ainswoth et al., 2011; Aranceta Bartrina, Pérez Rodrigo, & Alberdi Aresti, 2016).

Respondents were familiarized with the purpose of the research and given brief instructions on how to complete the questionnaire. The research was conducted anonymously, participation was voluntary, and it was conducted in accordance with ethical principles. It was approved by the Ministry of Education and Culture of the Republic of Srpska and the Republic Pedagogical Institute of the RS.

Statistical analysis

The basic parameters of descriptive statistics were calculated, (Mean) - arithmetic mean, (Std) - standard deviation, (Min) - minimum score, (Max) - maximum score. A regression analysis was calculated to determine the influence of levels of physical activity on the body image of the working population. To determine the influence of the predictor variables (level of physical parameters) on the criterion variable (Body image), a regression analysis was used. Statistical significance was determined at the level of $p < .05$. Statistical data processing was performed using the statistical package SPPS for Windows version 20 (IBM Statistics, SPSS, Chicago, IL, USA).

RESULTS

Table 1 shows the basic descriptive parameters of the variables for assessing physical activity and body image for the whole examined sample and by sex. The values of the arithmetic mean (Mean), the values of the minimum (Min.) and maximum (Max.) achieved results, and the standard deviation (Std.Dev.) are shown. Observing the mean values when it comes to physical activity, we can state that in working men the highest values were noted for Physical activity of high intensity (3315.70), followed by Physical activity of moderate intensity (2619.08), and Physical activity of low intensity (1632). Among working women, we can state that the highest value were noted for Physical activity of moderate intensity (1927.47), then Physical activity of high intensity (1893.16), and then Physical activity of low intensity (1688.91).

Table 1 Basic parameters of descriptive statistics

Variables	Men (n = 193)				Women (n = 307)				Total (n = 500)			
	Mean	St.Dev.	Min	Max	Mean	St.Dev.	Min	Max	Mean	St.Dev.	Min	Max
High Intensity Physical Activity (MET)	3315.70	2680.46	0.00	16800.00	1893.16	1855.93	0.00	14400.00	2597.34	2405.37	0.00	16800.00
Physical activity of moderate intensity (MET)	2619.08	2609.93	120.00	10080.00	1927.47	2225.01	0.00	14400.00	2242.22	2428.72	0.00	14400.00
Low Intensity Physical Activity (MET)	1632.52	1330.58	0.00	11088.00	1688.91	1575.96	99.00	9900.00	1662.63	1464.77	0.00	11088.00
Dissatisfaction with the body	9.62	13.05	-14.71	58.82	12.57	17.38	-29.41	58.82	11.43	15.90	-29.41	58.82
Dissatisfaction with the sexual body	11.80	16.72	-29.41	58.82	10.77	20.78	-44.12	58.82	11.16	19.31	-44.12	58.82
Comparative dissatisfaction with the body	-7.97	20.37	-58.82	44.12	-4.86	18.86	-58.82	58.82	-6.07	19.50	-58.82	58.82
Body dissatisfaction index	13.12	10.43	0.00	49.02	15.40	10.87	0.00	58.82	14.52	10.75	0.00	58.82

Legend: (Mean) - arithmetic mean, (Std) - standard deviation; (Min) - minimum score, (Max) - maximum score.

When observing the mean values of domains for the assessment of Body Image when it comes to working men, it can be seen that variables of dissatisfaction with the body (9.62), and dissatisfaction with the sexual body (11.80) have higher values, as does the index of dissatisfaction with the body (13.12), and lower values compared to body dissatisfaction (-7.97). In the sample of working women, higher values were noted for the variable of dissatisfaction with the sexual body (10.77), dissatisfaction with the body (12.57), and the index of dissatisfaction with the body (15.40), and lower values compared to dissatisfaction with the body (-4.86). Observing the mean values of the whole sample, it can be noticed that higher values are noticeable in the variables of dissatisfaction with the sexual body (11.16), dissatisfaction the with body (11.43), as well as with the index of dissatisfaction with the body (14.52).

Table 2 shows the results of the influence of physical activity parameters on the body image. Based on the obtained results, it can be concluded that at the multivariate level there is a statistically significant influence of physical activity on body dissatisfaction at the level of significance (sig = .009). To analyze the influence of individual variables on the criterion, the regression coefficient was standardized and the Beta value was obtained (Table 2). The higher its absolute value, the more influential the variable is on the criterion. The analysis of individual regression coefficients determined that a single variable of high-intensity physical activity (Sig = .013) has the greatest influence on dissatisfaction with the body.

The influence of physical activity on sexual dissatisfaction is shown in Table 2. The results of the regression analysis showed that there is a statistically significant influence of physical activity on sexual dissatisfaction at the .05 level of significance (Sig = .011). The analysis of individual regression coefficients shows that an individual variable, high-intensity physical activity (Sig = .042) has the greatest influence on dissatisfaction with the sexual body.

Based on the results of the regression analysis, we noticed that there is a statistically significant effect of physical activity on comparative dissatisfaction with the body at the level of significance .01 (Sig = .000). The analysis of individual regression coefficients shows that individual variables of high-intensity physical activity (Sig = .010) and low-intensity physical activity (Sig = .014) have the greatest influence on comparative dissatisfaction with the body .

Table 2 Influence of physical activity on Body Image parameters in the working population

		Beta	T	Sig.	Partial	R2	Sig
High intensity physical activity	Dissatisfaction of the body	-0.20	-2.50	**0.013**	-0.17	.055	**.009**
Physical activity of moderate intensity		-0.07	-0.98	0.327	-0.07		
Low intensity physical activity		0.01	0.10	0.923	0.01		
High intensity physical activity	Dissatisfaction with the sexual body	-0.16	-2.05	**0.042**	-0.14	.053	**.011**
Physical activity of moderate intensity		-0.03	-0.35	0.728	-0.02		
Low intensity physical activity		-0.01	-1.33	0.185	-0.09		
High intensity physical activity	Comparative dissatisfaction with the body	-0.20	-2.60	**0.010**	-0.18	.097	**.000**
Physical activity of moderate intensity		-0.18	-2.48	**0.014**	-0.17		
Low intensity physical activity		0.03	0.39	0.696	0.03		

Legend: Beta - standard partial regression coefficient of each predictor variable with the criterion; T-test; sig. - Significance level; Part R - partial correlation; R2 - coefficient of multiple determination of the variable and predictor system

The results of the influence of physical activity parameters on body dissatisfaction by gender, as well as the global influence of variables of physical activity on sexual body dissatisfaction are not tabulated. No statistically significant effect of physical activity on body dissatisfaction was determined, whether in the overall sample or it is in relation to gender. The significance level for the whole sample was Sig = .066; Sig = .347, and in men and women Sig = .132 and Sig = .225, respectively.

Table 3 shows the influence of physical activity on comparative dissatisfaction with the body in relation to gender. At the multivariate level, it was found that there is an impact of physical activity on comparative dissatisfaction with the body in both working men and working women. The level of significance in working men is .05 (Sig = .046), and in working women is .01 (Sig = .009). In working men, individual significant influence was found in high-intensity physical activity (Sig = .013), while in working women, the individual influence of physical activity on comparative dissatisfaction with the body was found in moderate physical activity (Sig = .001).

Table 3 Influence of physical activity on comparative dissatisfaction with the body in relation to gender

Comparative dissatisfaction with the body	Men				Women			
	Beta	Sig.	R2	Sig	Beta	Sig.	R2	Sig
High intensity physical activity	-0.27	**0.013**			-0.01	0.907		
Physical activity of moderate intensity	-0.02	0.804	0.042	**.046**	-0.37	**0.001**	0.126	**.009**
Low intensity physical activity	0.07	0.475			0.08	0.495		

Legend: Beta - standard partial regression coefficient of each predictor variable with the criterion; T-test; sig. - Significance level; Part R - partial correlation; R2 - coefficient of multiple determination of the variable and predictor system

The coefficient of multiple determination in the male population is R2 = .042, which explains the influence of physical activity parameters on body image with 4.2%, while in the female population the coefficient of multiple determination is R2 = 0.126, and it explains the influence of physical activity parameters on body image with 12.6%.

Table 4 shows the results of the influence of the level of physical activity on the body dissatisfaction index in men and women. Based on the obtained results, it can be stated that at the multivariate level there is a statistically significant influence of physical activity on the body dissatisfaction index in working men, with a significance level of (Sig = .026), while in working women the level of significance is negligible (.666).

Table 4 Influence of physical activity on the body dissatisfaction index in relation to gender

Body dissatisfaction index	Men				Women			
	Beta	Sig.	R2	Sig	Beta	Sig.	R2	Sig
High intensity physical activity	0.27	**0.011**			0.04	0.745		
Physical activity of moderate intensity	0.03	0.797	.052	**.026**	-0.06	0.589	.018	.666
Low intensity physical activity	-0.20	**0.050**			-0.11	0.330		

Legend: Beta - standard partial regression coefficient of each predictor variable with the criterion; T-test; sig. - Significance level; Part R - partial correlation; R2 - coefficient of multiple determination of the variable and predictor system

The analysis of individual regression coefficients shows that a single variable of high-intensity physical activity (Sig = .011), and low-intensity physical activity (Sig = .050), have the greatest influence on body dissatisfaction index in working men .

DISCUSSION

Since today's society places great emphasis on physical appearance (Tiggeman, 2004), it is not surprising that in recent years researchers have developed great interest in the topic of thinking and occupation with one's own body as well as its disorders (Furnham, Badmin, & Sneade, 2002). The conducted research aimed to determine the level of physical activity on the body image as well as the potential impact of the level of physical activity on the body image in relation to gender in the working population.

In the conducted research, it was determined that working women are less satisfied with their body compared to working men. The results obtained in this way are in line with the findings of some previous research on gender differences and body satisfaction. In a study by Lamb, Jackson, Cassidy, & Priest (1993) the results showed that in a sample of the general population women expressed greater body dissatisfaction compared to men. In doing so, dissatisfaction with the body was measured as a discrepancy between the current and ideal assessment of the body. Tiggemann (2004) attributes such results to women's greater concern for their body and appearance since they are of great importance in a woman's social success and valuation.

The results showed that there is a statistically significant effect of physical activity on the three domains (components) of the body image. However, some previous research has suggested that there may be a link between physical activity and body image (Williams & Cash, 2001) and that participation in physical activity may have an impact on an individual's body (Davis, Dionne, & Lazarus, 1994; Cranes,Waldron, Michalenok, & Stiles-Shipley, 2001; Furnham, Badmin, & Sneade, 2002). In contrast, Tiggemann and Williamson (2000) did not find a significant correlation between the level of physical activity and the appearance of the body, and used a general measure of physical activity that takes into account the different intensities of different activities. The more positive the body image, the more physically active a person is found to be, and vice versa, those who are dissatisfied with their body, more precisely with their own body image, have an inhibitory effect on exercise behavior and physical activity itself (Hu, 2017). According to research conducted by Sides-Moore and Tochkov (2011), a higher level of physical activity is indirectly associated with a better body image, and a lower urge to exercise, while physical activity is associated with upper quartile depression. Body image, both positive and negative, is an important factor, which plays a role in determining exercise habits (Sicilia, 2016). Silva, Sousa, Duca, and Peres, (2011) found a negative relationship between the amount of exercise and dissatisfaction with the body in younger women and assessed the amount of exercise using several physical activities (e.g. walking, running). We cannot rule out the possibility that respondents had difficulty solving the questionnaire, assessing the level of physical activity (IPAQ) in the sense that it was difficult for them to guess the exact time (in minutes) and number of days per week when they engaged in activities of different categories (intensity).

The influence of physical activity on comparative dissatisfaction with the body was found in both working men and working women. In men, the individual effect is noticeable in physical activity of high intensity, while in women the individual effect is determined in physical activity of moderate intensity. The results of the study show that the global impact of physical activity on the overall body dissatisfaction index exists only in working men. Individual effects were found in high-intensity physical activity and low-intensity physical activity.

The association between body image deficiency and physical activity has not yet been properly investigated in cognitive research, and there is little evidence of an association between body image and physical activity among men. Gender appears to play an important role in the relationship between body image and physical activity (Gillison et al., 2006), which was found in our study.

In some studies, it was found that the mechanisms that trigger the effects of physical activity on body image in men (Ginis et al., 2012) can be classified into three categories: objective changes in physical ability, observed changes in physical fitness, and changes in self-efficacy.

Physical activity is a possible way to improve health, and the amount of physical activity depends not only on gender, but also on body image. Men with a negative body image are less physically active than other men (Zach & Netz, 2014). The challenge in health promotion is to preserve their relatively good perception of body image while promoting physical activity. Prevention programs should focus on the perception of body image while promoting physical activity. Prevention programs should be aimed at adults by highlighting and promoting healthy lifestyles for both adult men and women (Jurakić, 2009).

Although most research on physical dissatisfaction of adult respondents (over the age of 18) focuses on women, there are also studies that have examined this issue among adult men (Pingitore, Spring, & Garfield, 1997). Studies seem to suggest that body dissatisfaction among adult men is not as simple as in adult women. In contrast, some adult men appear to strive for a lean body, while others want a larger, more muscular body (Meyer, Blissett, & Oldfield, 2001). In general, the literature suggests that women attach more importance to the appearance of their body than men. This finding regarding the importance of body image was supported by the findings of Rozin and Fallon (1988), who found that although adult men and women expressed a desire to lose weight, women showed greater concern about weight and diet. In a meta-analysis of gender differences in attractiveness, Feingold and Mazzella (1998) found that men are more satisfied with their bodies than women, and consider themselves more attractive. These results may indicate that gender does not shape the body image of adult men, but that that men are more likely to accept a male sexual role and also aspire to a stereotypical ideal male body. In their study, Pope et al. (2000) found that men from France, Austria, and America stated on average: that their ideal body was 13 kg more muscular than their current one. In fact, it seems that it is precisely those men who show the greatest desire for increased build and show the greatest level of dissatisfaction with the body. These findings would be expected to apply to men who are more involved in physical activity. However, McDonald and Thompson (1992) found that men who were physically active were less likely to show a high level of physical dissatisfaction than physically active women. The findings of these various studies suggest that the nature of exercise adopted by men may reflect different levels of body dissatisfaction, and that high levels of exercise do not necessarily mean that men also experience high levels of body dissatisfaction (Demarest, & Allen, 2000).

CONCLUSION

Physical inactivity is a global problem despite the known benefits of physical exercise. Sufficient physical activity, along with numerous health, psychological, social, and economic positive effects, affects satisfaction with physical appearance. In this paper, the influence of physical activity on the body image of working men and women was investigated.

Based on the obtained results, it can be generally concluded that physical activity affects the body image of the working population in different ways. Observed in relation to gender, it was found that physical activity has a significant impact on the body image in the domains of comparative dissatisfaction body and the Body dissatisfaction index in the working male population.

Because physical dissatisfaction can cause serious health problems such as anxiety, depression, and eating disorders, we can conclude that the positive association between physical activity and physical satisfaction increases physical activity levels, especially in the male population. Individual variables of high-intensity physical activity can contribute to a more positive perception of physical appearance, which indirectly affects better health.

In order to determine the possible effects of physical activity on body image in more detail for men and women separately, there is a need for further research regarding the moderators and mechanisms of the relationship between physical activity and body image.

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FIZIČKE AKTIVNOSTI I SLIKA O TELU MEĐU RADNO AKTIVNIM STANOVNIŠTVOM

Cilj istraživanja bio je da se utvrdi uticaj fizičke aktivnosti na sliku o telu radno sposobnog stanovništva. Populaciju iz koje je definisan uzorak ispitanika činilo je radno aktivno stanovništvo, prosečne starosti 44 godine. Ukupan uzorak činilo je 500 ispitanika, od čega 193 muškarca i 307 žena. Fizička aktivnost određena je korišćenjem kratke forme IPAK upitnika, a nivo fizičke aktivnosti u tri domena: fizička aktivnost visokog intenziteta, fizička aktivnost umerenog intenziteta i fizička aktivnost niskog intenziteta. Za procenu slike o telu korišćena je skala fizičkog izgleda koja se sastoji od četiri pitanja na koja je trebalo odgovoriti koristeći skalu u rasponu od 1,8 do 5,2. Na osnovu dobijenih rezultata utvrđeno je da postoji statistički značajan uticaj fizičke aktivnosti na sliku o telu i to na nezadovoljstvo telom na nivou značajnosti .01 (Sig = .009), na uporedno nezadovoljstvo telom na nivou značajnosti .01 (Sig = .000) i nezadovoljstvo seksualnim telom na nivou značajnosti .05 (Sig = .011) na ukupnom uzorku. Individualni uticaj nivoa fizičke aktivnosti u odnosu na pol utvrđen je kod zaposlenog stanovništva u domenu komparativnog nezadovoljstva telom (Sig = ,032) i na indeksu nezadovoljstva telom (Sig = ,026). Autori zaključuju da nivo fizičke aktivnosti značajno utiče na sliku o telu i ukazuju na značaj bavljenja fizičkom aktivnošću u cilju poboljšanja slike o telu, posebno kod zaposlenih muškaraca.

Ključne reči: *fizička aktivnost, slika o telu, radno aktivno stanovništvo*

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