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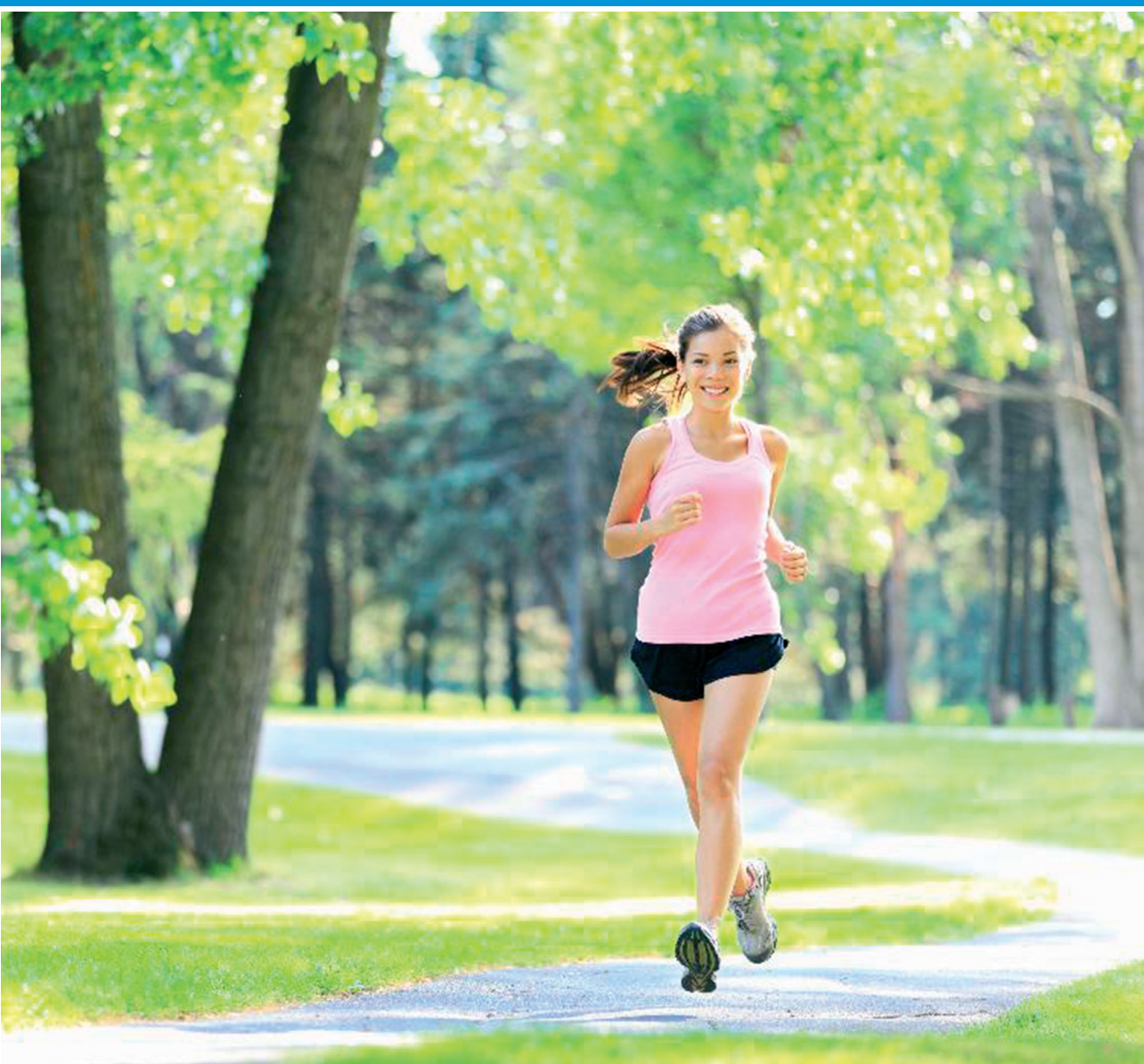

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Research article

TRAINING LOAD DEMANDS MEASURED BY SURFACE ELECTROMYOGRAPHY WEARABLE TECHNOLOGY WHEN PERFORMING LAW ENFORCEMENT-SPECIFIC BODY DRAGS

UDC 796.015

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Abstract. *The use of surface electromyography (sEMG) wearable technology to measure training load (TL) during law enforcement-specific tasks (e.g. a body drag) requires investigation. This study determined muscle activation differences represented as TL during a 9.75-m drag with 74.84 kg and 90.72 kg dummies. Eight men and three women were fitted with a compression short or legging embedded with sEMG wearable technology to measure the quadriceps (QUAD; vastus medialis+vastus lateralis), biceps femoris (BF), and gluteus maximus (GM). After fitting on day one, participants completed maximal voluntary isometric contractions for each muscle to normalize the sEMG signal and calculate TL units. On days two and three, participants performed a 9.75 m body drag using either the 74.84 kg or the 90.72 kg dummy while wearing the technology. Participants lifted the dummy off the floor to a standing position and dragged it as quickly as possible over 9.75 m. Paired samples t-tests calculated between-drag differences for: time; QUAD, BF, GM, and total TL; and QUAD-BF, GM-BF, anterior-posterior (QUAD-GM+BF) ratios. QUAD TL was 9% greater (p=0.035), and GM TL was 8% lower (p=0.043), in the 90.72 kg body drag compared to the 74.84 kg drag. There were no between-mass differences in time, BF TL, total TL, or the ratios. QUAD TL increased while GM TL decreased when participants dragged a 90.72 kg dummy. As drag time was not different between the masses, drag mechanics may have changed leading to increased QUAD TL. sEMG wearable technology could be a useful method to measure TL in law enforcement-specific dragging tasks.*

Key words: *Casualty Drag, Law Enforcement, Muscle Activation, Police, Tactical, Victim Drag*

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INTRODUCTION

Law enforcement can be a demanding profession and can place great deal of physical stress on those employed in this job. On-duty law enforcement officers (LEOs) may be required to push, pull, lift, carry, or drag objects or people at any time during their shift (Dawes et al., 2016). LEOs must also perform job-specific skills, including driving vehicles (Lockie, Dawes, Kornhauser, Holmes, & Orr, 2018c), discharging firearms (Kayihan, Ersöz, Özkan, & Koz, 2013; Orr, Pope, Stierli, & Hinton, 2017), defensive tactics (Mitrović et al., 2016; Orr et al., 2017; Dawes et al., 2018; Lockie et al., Cesario, Bloodgood, & Moreno, 2018a), vaulting obstacles, and pursuing and apprehending suspects (Dawes et al., 2017a; Schram, Hinton, Orr, Pope, & Norris, 2018a; Schram, Orr, Pope, Hinton, & Norris, 2018b). One of the more physically demanding critical job tasks is the body drag, where LEOs must rapidly drag an incapacitated civilian or colleague from a hazardous environment (Lockie et al., 2018b; Lockie, Balfany, Denamur, & Moreno, 2019b; Moreno et al., 2019). As successful completion of this task could determine the survival of all involved, the body drag is often incorporated into job-specific testing to ascertain physical readiness for policing. As an example, a 9.75 m body drag with a 74.84 kg dummy is a task in the Work Sample Test Battery for Californian law enforcement recruits, which they must successfully complete before they graduate academy (Peace Officer Standards and Training, 2012; Lockie et al., 2018b; Lockie, Balfany, Denamur, & Moreno, 2019b; Lockie, Orr, Moreno, Dawes, & Dulla, 2019e; Moreno et al., 2019).

However, it is questionable whether the 74.84 kg dummy is representative of the current USA population. Recent data has shown that the average adult female in the USA weighs approximately 76-77 kg, while the average adult male weighs almost 90 kg (Fryar, Gu, Ogden, & Flegal, 2016). Further issues arise if an LEO has to drag one of their colleagues. Previous research on incumbent LEOs has reported mean body masses of 68-77 kg for women and approximately 92 kg for men (Dawes et al., 2017b; Lockie, Dawes, Kornhauser, & Holmes, 2019c). LEOs may also be carrying approximately 8-22 kg of equipment while on duty (Joseph, Wiley, Orr, Schram, & Dawes, 2018). These data seem to indicate that the dummy mass should be increased from 74.84 kg to a load commensurate with either the general population (~90 kg) (Fryar et al., 2016) or fellow LEOs with their duty load (~100 kg) (Baran, Dulla, Orr, Dawes, & Pope, 2018) to better prepare recruits for this task. Before that can be considered, it would be of interest to know the demands associated with dragging individuals of different masses during a law enforcement-specific body drag.

Tactical populations, predominantly the military, have started using technology more associated with elite sport (Friedl, 2018). The integration between these processes has been done to ensure trainees experience the appropriate load to attain the desired training adaptations, and to reduce injuries (Jones, Hauschild, & Canham-Chervak, 2018). The challenge for law enforcement populations is finding technology that can be used when in physical training attire or uniform that can directly measure specific tasks when performed in the field. One example of emerging technology that could have practical application in policing is surface electromyography (sEMG) wearable technology. This system evaluates the activation of muscles during physical activity, and can use these measurements as an indicator of training load (TL) (Lynn, Watkins, Wong, Balfany, & Feeney, 2018). The measurement of TL via wearable technology provides a measure of

the resultant stress placed on the body by the performed activity (Jones, Griffiths, & Mellalieu, 2017). This would appear to have value for law enforcement, as sEMG wearable technology can be worn under training attire or uniforms, and could be used to ascertain the TL via muscle activation during tasks such as the body drag.

Thus, the purpose of this research note was to determine if the TL and muscle activation patterns required to drag a 74.84 kg or 90.72 kg dummy changed during a 9.75 m drag in recreationally-trained males and females. Wearable technology with built-in sEMG sensors measured muscle activation during the drags. It was hypothesized that the 90.72 kg body drag would be performed slower than the 74.84 kg drag. In accordance with this, it was further hypothesized that a greater TL would be recorded during the 90.72 kg body compared to the 74.84 kg drag. This study provided an initial analysis of the potential use of this equipment to measure the stress incurred by a specific law enforcement task, within the context of population demographic changes (Fryar et al., 2016) and the mass of LEOs (Dawes et al., 2017b; Lockie et al., 2019c). This study will provide useful information which could have health and exercise implications for law enforcement populations.

METHODS

Participants

A convenience sample of 11 physically active participants, including eight males (age=25.50±5.66 years; height=1.78±0.06 m; body mass=82.86±6.15 kg) and three females (age=24.33±2.52 years; height=1.71±0.04 m; body mass=73.87±9.51 kg) completed this study. Participants were recruited from the student population at the university via information sessions and word-of-mouth on campus. Civilians were used as surrogates for a tactical population (Williams-Bell, Villar, Sharratt, & Hughson, 2009; Mala et al., 2015; Nindl et al., 2017; Stevenson, Siddall, Turner, & Bilzon, 2017; Lockie et al., 2019b), and were age-matched to law enforcement recruits (Boyce, Jones, Schendt, Lloyd, & Boone, 2009; Crawley, Sherman, Crawley, & Cosio-Lima, 2016). Additionally, the physical qualities important for a tactical task such as the body drag should be similar whether they are performed by a tactical operator or civilian (Stevenson et al., 2017; Lockie et al., 2019b). Previous research has demonstrated minimal learning effects with a military-style body drag (Foulis et al., 2017). This should mean that even for participants who were not law enforcement recruits or officers, they should perform the body drag with consistency across trials. No participants have previously been involved with law enforcement training. Participants self-reported whether they completed the minimum recommended physical activity guidelines for cardiorespiratory and musculoskeletal fitness for adults as detailed by the American College of Sports Medicine (Garber et al., 2011), and were required to be free from any musculoskeletal disorders that could influence study participation. The institutional review board approved the study (HSR-18-19-109), all participants received an explanation of the procedures, and written informed consent was obtained. The study still conformed to the recommendations of the Declaration of Helsinki (World Medical Association, 1997).

Procedures

Participants completed three testing sessions separated by 48-72 hours. On day one, participants had their age, height, and body mass recorded. Height was measured barefoot using a portable stadiometer (Detecto, Webb City, MO, USA), while body mass was recorded by electronic digital scales (Ohaus, Parsippany, NJ, USA). Waist and hip circumference were measured to determine the garment size, before participants were fitted with the sEMG wearable technology (Athos, Redwood City, California). Males wore compression shorts, females wore leggings, and each were embedded with sEMG sensors that measured the vastus medialis (VM), vastus lateralis (VL), biceps femoris (BF), and gluteus maximus (GM) for each leg. The sensors provided a bipolar differential sEMG measurement with an inter-electrode distance of 2.1 cm and were comprised of a conductive polymer. No skin or electrode preparation was performed at the site corresponding to each electrode as this aligned with recommended product usage (Lynn et al., 2018). Participants then completed a standard dynamic warm-up, which was also used on days two and three. Participants cycled for 5 minutes at a self-selected intensity on a bicycle ergometer (Assault Fitness, Carlsbad, California), before completing approximately 10 minutes of full-body dynamic stretching. Participants refrained from intensive lower-body exercise and maintained a standardized dietary intake in the 24-hour period prior to each testing session, and were permitted to consume water as necessary throughout each testing session.

After the warm-up on day one, participants completed maximum voluntary isometric contraction (MVIC) assessment via manual muscle testing for each leg which was used to normalize the sEMG data (Burden, 2010; Aquino & Roper, 2018). This followed manufacturer guidelines to use an MVIC recorded on a different testing day to ensure practicality of use for the technology. Internal testing showed that this normalization procedure for all muscles displayed similar results to MVICs performed on an isokinetic dynamometer (r>0.8, p<0.001) (Balfany, Chan, Lockie, & Lynn, 2019). To measure the quadriceps (QUAD; VM+VL) MVIC, participants sat on a table with their knees bent to 90°. The participant tried to extend the knee with maximal force while the researcher applied maximal resistance just above the ankle. To measure the BF MVIC, the participant lay prone on the table with the measured leg flexed at the knee to 90°. The researcher provided maximal resistance, pulling the shank away from the participant as they simultaneously pulled their foot toward their buttocks. The participant stayed in the same position to measure the GM MVIC. The researcher provided maximal force downward on the participant's foot as the participant extended at the hip. The participant performed three repetitions of each MVIC trial for 5 seconds each, with 60 seconds rest between trials (Balfany et al., 2019). Familiarization to the body drag was also completed on day 1, such that participants achieved the required body drag techniques for the subsequent testing sessions. Participants completed several practice drags as required with both dummies.

All sEMG data was transmitted via Bluetooth technology embedded in a core that sat in the shorts or leggings. Data was sent to an iOS device (Apple Inc., Cupertino, California) with the software app where pre-programmed sessions logged the data. The technology processed the data independently and distributed a measurement of TL for combined muscle groups and a measure of integrated EMG (area under the curve of the rectified EMG signal). The integrated EMG for each muscle was measured as a percentage of MVIC and when combined, calculated the TL for the muscles. TL metrics were reported as arbitrary units

(AU); a single 'AU' was equivalent to one muscle activating at 100% of the MVIC for one second. The variables included: QUAD, BF, GM, and total TL; and muscle ratios [QUAD-BF; GM-BF, and anterior-to-posterior (A-P; QUAD-BF+GM)]. These muscle ratios were specific to the app, and were included for exploratory analysis in this research note.

Body Drag

Body drag testing was conducted in days two and three, and followed protocols used in California for law enforcement recruits (Lockie et al., 2019b; Lockie et al., 2018b; Lockie et al., 2019e; Moreno et al., 2019; Peace Officer Standards and Training, 2012). The mass dragged each day (either the 74.84 kg or 90.72 kg dummy) was counterbalanced amongst the sample. All trials were performed on a wooden floor, with tape marking the start and finish lines for the 9.75-m dragging distance. The dummies (Dummies Unlimited, Pomona, California) were positioned face side up, with the head orientated towards the finish line, and the feet 0.3 m behind the starting line. As shown in Figure 1, participants picked the dummy up by wrapping their arms underneath the arms of the dummy and lifting it to a standing position (Peace Officer Standards and Training, 2012; Lockie et al., 2018b; Lockie et al., 2019b; Lockie et al., 2019e; Moreno et al., 2019). Once standing, the participant informed the researcher they were ready, and timing was initiated when the feet of the dummy passed the start line via stopwatch by a researcher trained in the use of stopwatch procedures (Peace Officer Standards and Training , 2012; Lockie et al., 2019b; Lockie et al., 2018b; Moreno et al., 2019). Testers trained in the use of stopwatch timing procedures for athletic performance tests can record reliable data (Hetzler, Stickley, Lundquist, & Kimura, 2008). Participants dragged the dummy as quickly as possible by walking backwards over the required distance. Timing stopped when the dummy's feet crossed the finish line, and was recorded to the nearest 0.1 second. Two trials were completed for the drags with each mass, with three minutes rest between trials. The wearable technology recorded data for the duration of all body drags.

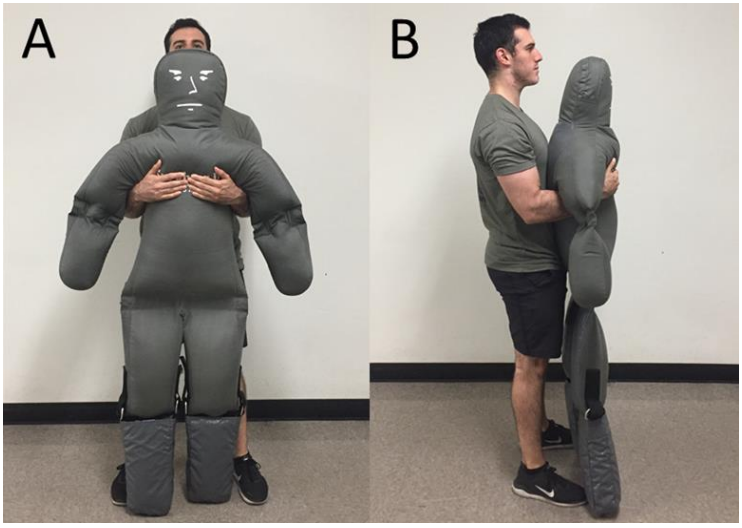

Fig. 1 Starting position for the body drag

Statistical Analysis

All statistics were computed using the Statistics Package for Social Sciences Version 25.0 (IBM, Armonk, United States of America). Descriptive statistics (mean±SD) profiled all variables, and data was combined between the sexes. Previous law enforcement specific-research has combined data for the sexes (Cesario et al., 2018; Lockie et al., 2018d; Lockie et al., 2018e; Lockie et al., 2019c; Lockie et al., 2019d; Lockie et al., 2020; Bloodgood et al., in press). This approach was taken in this study as well because the focus was on the absolute effects of the dummy masses on TL regardless of sex. Paired samples t-tests compared drag time, QUAD, BF, GM, and total TL, and muscle ratios between the two masses. Significance was set a priori at $p<0.05$.

RESULTS

Table 1 displays the data recorded from each drag. No significant differences were found between the 74.84 kg body drag time versus the 90.72 kg drag time. In the 90.72 kg body drag, QUAD TL was significantly greater (9%), and GM TL was significantly lower (8%) compared to the 74.84 kg body drag. There were no significant differences between the masses in BF TL, total TL, or the between-muscle ratios.

Table 1 Descriptive data (mean±SD) for time, QUAD (VM+VL) TL, BF TL, GM TL, and total TL, and muscle ratios (QUAD:BF, GM:BF, and A:P) for the 74.84 kg and 90.72 kg body drags

Variables	74.84 kg Body Drag	90.72 kg Body Drag	*p*-value
Time (s)	6.57 ± 2.50	6.75 ± 2.56	0.340
QUAD TL (AU)	12.22 ± 6.35	13.26 ± 7.20*	0.035
BF TL (AU)	9.22 ± 4.23	9.69 ± 4.63	0.629
GM TL (AU)	5.96 ± 4.31	5.46 ± 4.09*	0.043
TOTAL TL (AU)	27.41 ± 12.13	28.43 ± 13.42	0.482
QUAD:BF	0.86 ± 3.45	0.89 ± 0.31	0.653
GM:BF	0.65 ± 0.33	0.57 ± 0.25	0.168
A:P	0.90 ± 0.45	0.97 ± 0.41	0.216

* Significantly (<0.05) different from the 74.84 kg body drag.

DISCUSSION

This study determined whether the TL and muscle ratios required to drag a 74.84 kg or 90.72 kg dummy during a 9.75 m drag were different in trained males and females. Although a law enforcement-specific task was analyzed with civilians, this approach has been adopted in other tactical research (Williams-Bell et al., 2009; Mala et al., 2015; Stevenson et al., 2017; Nindl et al., 2017; Lockie et al., 2019b). The analysis of the TL derived from the body drag performed with 74.84 kg or 90.72 kg dummies was important, as the current dummy mass for Californian law enforcement recruits is below that of the general population (Fryar et al., 2016) and many LEOs (Dawes et al., 2017b; Lockie et al., 2019c). Firstly, there were no differences in the drag time for each mass. The testing

conditions could have influenced these results, as the lifting component was not included in the time (Peace Officer Standards and Training, 2012; Lockie et al., 2018b; Lockie et al., 2019b; Moreno et al., 2019). Including the lifting time in the body drag increases the total time recorded, which is exacerbated even more when a participant has to drag a heavier mass (Lockie et al., 2019b). Furthermore, participants had to be strong enough to lift the dummy mass from the ground. This could reduce the friction encountered as less of the dummy is in contact with the ground, allowing for similar times between the masses.

QUAD TL was greater in the 90.72 kg body drag compared to the 74.84 kg body drag, while GM TL was lower. Specific to the QUAD, an increase in TL could be the result of an increase in task completion time or an increase in stress placed on the muscles as a result of the external load. As the body drag time measured in this study was not different between the masses, it could be assumed the drag mechanics changed, leading to increased demands on the QUAD (and reduced demands on the GM). The body drag, especially how it was performed in this study (Peace Officer Standards and Training, 2012; Lockie et al., 2018b; Lockie et al., 2019b; Lockie et al., 2019e; Moreno et al., 2019), has some similarities to a deadlift. In an analysis of lower-body strength exercises, Schellenberg, Taylor, & Lorenzetti (2017) found that the quadriceps were most active in the deadlift. The need to physically stand with the dummy by extending the legs could have increased the QUAD TL. This is useful information when considering the use of wearable technology in law enforcement, the stress associated with lifting external loads, and the relevance of lifting tasks for LEOs (Anderson, Plecas, & Segger, 2001). Specific to law enforcement recruits and officers, the adoption of training exercises that stress the QUAD could be useful in training to enhance their ability to complete dragging tasks. Some examples include deadlifts with a conventional or hexagonal bar (Camara et al., 2016) and sled drags (Jenkins & Palmer, 2012). The ability for the QUAD to tolerate load during a dragging task especially important to develop, given the heavier citizens (Fryar et al., 2016) or colleagues (Dawes et al., 2017b; Lockie et al., 2019c) LEOs may encounter during their shift.

These data are important when considering the implications of measuring TL. In athletes, TL is essential for understanding the individual's response to training (Halson, 2014). A unique aspect to this study was the use of sEMG wearable technology to measure the demands of the body drag with different masses. The TL derived from muscle activation provides a new internal load metric (Chan, 2017). Further to this, the sEMG wearable technology appeared to provide a useful measure of the stress imposed by the body drag, as QUAD TL increased with the heavier mass. Previous research has used this technology to measure push-ups and body weight squats (Aquino & Roper, 2018) and isokinetic knee flexion and extension (Lynn et al., 2018). This is the first study to measure a law enforcement-specific task such as the body drag. These data have further use when considering how law enforcement physical training is often conducted at the academy. If TL monitoring via equipment such as sEMG wearable technology is utilized, it can allow for monitoring of the variations that occur between individuals. This is prescient when considering the 'one-size-fits-all' model of physical training commonly completed by law enforcement recruits (Orr, Ford, & Stierli, 2016; Moreno, Cesario, Bloodgood, & Lockie, 2018; Cesario, Moreno, Bloodgood, & Lockie, 2019; Lockie et al., 2019a). This would result in great variations between the TL experienced by individuals. Although further research is needed to further validate this equipment, sEMG

wearable technology could be a useful tool in measuring the TL associated with typical law enforcement tasks during training, and potentially when on-duty.

There were no differences between the two drags in BF TL, total TL, and the between-muscle ratios. There was a non-significant, 14% decrease in the GM:BF ratio in the 90.72 kg body drag, which may have been a function of the reduced GM TL. Regarding the total TL, as QUAD TL increased, GM TL decreased in the 90.72 kg body drag versus the 74.84 kg drag, providing some indication as to why total TL was not different between the masses. Furthermore and as noted, there were no between-mass differences in drag time. A longer drag should result in a greater total TL due to the increase in task completion time. Nonetheless, this concept requires further analysis in LEOs. If an LEO is slower in job-specific tasks, not only is this less effective, but could also result in a greater TL being experienced. This could increase the likelihood of fatigue (Halson, 2014), which could hamper further job task performance.

There are some study limitations that should be noted. This study did not use law enforcement recruits or officers, although as stated, the use of civilians to analyze tactical tasks has been adopted in other studies (Williams-Bell et al., 2009; Mala et al., 2015; Nindl et al., 2017; Stevenson et al., 2017; Lockie et al., 2019b). This is because the physical qualities important for a tactical task such as a body drag should be similar whether they are performed by a tactical operator or civilian (Stevenson et al., 2017; Lockie et al., 2019b). The sEMG wearable technology used in this research only measured muscles in the lower-body, even though the body drag is a full-body activity. Future studies should incorporate sEMG wearable technology that also measures upper-body muscle TL. In addition to this, long-term studies are required to confirm the viability of sEMG wearable technology to measure TL in law enforcement populations. The sEMG wearable technology needs to be validated against other equipment that also measures TL (e.g. global positioning system technology, heart rate, rating of perceived exertion) to confirm its viability. The sample size was small (N=11), for both males (n=8) and females (n=3). Larger sample sizes should be used in forthcoming studies analyzing TL demands during law enforcement-specific tasks such as the body drag.

CONCLUSIONS

Although more research is required, this study provided some initial data that suggested sEMG wearable technology could be a useful tool to measure TL in law enforcement-specific tasks such as 74.84 kg and 90.72 kg body drags. Moreover, the data indicated that QUAD TL increased and GM TL decreased in participants when they dragged a 90.72 kg dummy versus a 74.84 kg dummy, suggesting changes to the mechanics associated with lifting the heavier mass. The measurement of data such as this could influence the training of dragging tasks for law enforcement recruits. That is, law enforcement recruits and officers should incorporate exercises that develop the ability of the QUAD to tolerate load during dragging tasks. Lastly, there is potential for the use of sEMG wearable technology to measure TL during law enforcement training for recruits, and potentially when on shift for LEOs.

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TRENAŽNA OPTREĆENJA MERENA NOSIVOM POVRŠINSKOM ELEKTROMIOGRAFIJOM PRILIKOM IZVOĐENJA SPECIFIČNOG POVLAČENJA TELA OD STRANE PRIPADNIKA POLICIJE

Upotreba tehnologije površinske elektromiografije (sEMG) za merenje trenažnih opterećenja (TO) tokom specifičnih policijskih zadataka (npr. povlačenje tela) zahteva istraživanje. Ovim istraživanjem utvrđene su razlike u aktivaciji mišića predstavljene kao TO tokom povlačenja u rastojanju od 9.75 m sa lutkama mase 74.84 kg i 90.72 kg. Osam muškaraca i tri žene opremljeni su prslucima sa ugrađenom sEMG nosivom tehnologijom radi merenja aktivnosti kvadricepsa (QUAD; vastus medialis+vastus lateralis), biceps femoris (BF) i gluteus maximus (GM). Nakon prilagođavanja tokom prvog dana, učesnici su izveli maksimalne izometrijske kontrakcije svakog od navedenih mišića zbog normalizacije sEMG signala i izračunavanja TL jedinice. Tokom drugog i trećeg dana, učesnici su izveli povlačenje tela u rastojanju od 9.75 m koristeći lutke mase 74.84 kg i 90,72 kg i nosivu sEMG tehnologiju. Učesnici su lutku podigli sa poda u uspravni položaj i povukli je što je brže moguće u rastojanju od 9.75 m. T-testom za uparene uzorke izračunate su razlike u povlačenju za: vreme; QUAD, BF, GM i ukupan TL; i odnose QUAD-BF, GM-BF, prednji-zadnji (QUAD-GM+BF). QUAD TL je bio 9% veći (p=0.035), a GM TL 8% niži (p=0.043), prilikom povlačenja lutke mase 90.72 kg u odnosu na povlačenje lutke mase 74,84 kg. Nije bilo razlika između mase u vremenu, BF TL, ukupnog TL ili navedenih odnosa. QUAD TL je porastao, dok se GM TL umanjio kada su učesnici povlačili lutku od 90.72 kg. Kako se vreme vuče između masa nije razlikovalo, možda se promenila mehanika vuče što je dovelo do povećanja QUAD TL. Tehnologija nošenja sEMG-a mogla bi da bude od korisna metoda za merenje TL-a u zadacima vuče tela.

Ključne reči: *vuča povređenih*, *sprovođenje zakona*, *aktivacija mišića*, *policijske snage*, *taktika*, *vuča žrtava*

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Research article

MECHANICAL AND FUNCTIONAL CHARACTERISTICS OF HAND GRIP STRENGTH IN YOUNG FEMALE HANDBALL PLAYERS

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Abstract. *The aim of this research was to define differences in functional and mechanical characteristics of isometric hand grip (HG) strength between young female handball players and the CG comprised of physically active girls with no experience in sport. 70 individuals participated in the research, 36 of whom were the best young female handball players (of cadet and junior categories) while 34 girls comprised the CG. The results obtained show that the young female handball players who took part in the tests achieved F_{max} at the levels from 306.4±40.8 to 335.5±47.0 N and RFD_{max} at the levels ranging from 1918.1±366.8 to 2174.4±382.1 N/s for the non-dominant and dominant hand. When these results are compared to the ones achieved by the CG it is clear that the young female handball players had a statistically significant higher level of the maximum HG force of both arms as well as the higher level of maximum explosiveness. There was no statistically significant difference between the groups regarding all the indexes of dimorphism (ID) as well as the values of the time needed for achieving the maximum intensity of muscle excitation ($tRFD_{max}$). Therefore, it can be concluded that the handball players who underwent the testing procedures showed positive adaptation from the aspect of the mechanical characteristics of hand grip strength, which can most likely be ascribed to the phenomenon of biological adaptation to the training stimuli characteristic for handball. However, the same influence was not detected from the aspect of functional characteristics, more precisely, dimorphism.*

Key words: *Handball, Mechanical Muscle Properties, Hand Grip Test*

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INTRODUCTION

The arms and the hands represent a specialised part of the body responsible for manipulative tasks with different objects. They are able to realise different movements in all three axes with various types of load, with different grip and pinch grip activities, using different intensities (Tyldesley & Grieve, 1996). Proper muscle force production is of crucial importance for any kind of gripping and for this reason the contractile characteristics (functional and mechanical) of hands are one of the most important limiting factors in all upper body motor and manipulative activities (Leyk et al., 2007; Tanner & Gore, 2013).

According to the performance analysis it is well known that handball represents a dominantly high-intensity sports game, with intermittent motor structure and active body contact technical elements of playing (Matthys et al., 2011). As a game in which powerful contacts are very common, handball is a sport which requires high levels of morphological, physical, motor, functional and cognitive positive adaptation, as a consequence of selection and a long-term high intensity training process (Chaouachi et al., 2009; Ingebrigsten & Jeffreys, 2012; Dopsaj, Valdevit, Ilić, Pavlović, & Petronijević, 2017; Tosun, Koç, & Őzen, 2017; Pavlović, Bojić, Stojiljković, Đorđević, & Radovanović, 2018; Petković, Bubanj, Marković, Kocić, & Stanković, 2019; Marković et al., 2019).

One of the most important segments of the long-term development in athletes is devising a long-term system for monitoring and controlling the levels of their readiness, which implies checking the levels of correlation between the crucial motor, physiological and psychological characteristics regarding the sport or the discipline they train (Chaouachi et al., 2009; Matthys et al., 2011). The adequate system of testing with statistical and mathematical procedures used for calculating the most relevant models for optimal monitoring of athletes' performance is one of the crucial segments in the modern technology of creating elite athletes (Tanner & Gore, 2013; Dopsaj et al., 2017; Dopsaj, Valdevit, Vučković, Ivanović, & Bon, 2019[a]).

The main aim of the handball game is to score a goal to the opponent team in accordance with the rules of the game. Among the other important motor skills, such as running, jumping, change of direction etc., ball manipulation is the most important one. Generally, a handball player should be capable of performing different techniques with the ball such as catching, gripping, holding, bouncing, feigning, receiving, passing and finally shooting. In all those techniques, hand and finger manipulation skills with contractile abilities of the responsible muscles have an extremely important role (Tyldesley & Grieve, 1996).

The Hand grip test (HG) is the golden standard test for measuring mechanical muscle characteristics, as follows: achieved maximal muscle force (F_{max}), achieved rate of force development (RFD) as a measure of muscle explosiveness, and different time and index parameters (Sahaly, Vandewalle, Driss, & Monod, 2001; Demura et al., 2003; Leyk et al., 2007; Gallup, White, & Gallup Jr, 2007; Dopsaj et al., 2019[b]). There is strong evidence in the scientific literature that HG is highly reliable when it comes to estimating physical abilities as well as genetic, biological and behavioural potentials of a person. It has also been proven that it represents a simple marker of general body power and strength in children, adolescents, young people and adults regardless of gender (Bohannon, 2001; Frederiksen et al., 2002; Wind, Takken, Helders, & Engelbert, 2010; Atkinson et al., 2012; Sayer & Kirkwood, 2015; Marković, Dopsaj, Koropanovski, Ćopić, & Trajkov, 2018[a]; Dopsaj et al., 2019[b]).

The aim of this research was to define the differences in functional and mechanical characteristics of HG strength between young female handball players, and the control group comprised physically active girls with no experience in sport. The practical value of this study lies in obtaining scientific information on the sensitivity of the method of testing and the test used, but also in defining the most valid mechanical and functional variables for the purpose of improving the testing system of top young female handball players.

METHODS

In this study the method used was laboratory testing, while the applied research design was a Cross-Sectional study with a direct measurement protocol. The study was applied according to the standards for research methods in sport (Thomas, Silverman, & Nelson, 2015).

Sample

70 individuals participated in the research, 36 of whom were the best young female handball players (of cadet and junior categories) who participated in training camps during the 2018 season and 34 girls of the same age without any experience in sport comprising the control group. The basic anthropomorphological characteristics of the players were: Age=16.6±1.1 yrs, BH=173.2±5.8 cm, BM=69.7±7.9 kg, BMI=23.20± 1.93 $kg \cdot m^{-2}$, PBF=22.58±4.46% and PSMM=43.39±2.53%, and of the control group members: Age=16. 3±1.7 yrs, BH=169.5±8.3 cm, BM=61.0±9.6 kg, BMI=21.11±2.11 $kg \cdot m^{-2}$, PBF=23.08±4.75% and PSMM=42.25±2.72 $kg \cdot m^{-2}$.

Testing

For the evaluation of the isometric hand grip (HG), a protocol with standardized procedures and equipment (All4gym d.o.o., Serbia) was used, i.e. a sliding device with a fixed tensiometric strain gauge (Marković et al., 2018[a]; Zarić, Dopsaj, & Marković, 2018; Marković, Dopsaj, Koprivica, & Kasum, 2018[b]; Dopsaj, Prebeg, & Kos, 2018; Dopsaj et al., 2019[b]). It was established earlier that the used equipment has a high level of measurement reliability whereby ICC ranges from 0.938 to 0.977 for F_{max}, and from 0.903 to 0.971 for RFD_{max} variables (Marković et al., 2018[a]). The participants were sitting upright in the middle of the chair during the test. The arm of the tested hand was in a natural stretched position, alongside and placed in an abduction position 5 to 10 cm away from the body. The arm of the non-tested hand was resting alongside the body and the participants were not allowed to move during the test.

Prior to the experimental trials of the HG test, each participant was given a detailed test explanation and they performed a pre-trial measurement, for the purpose of becoming familiar with the procedure, alternating hands at sub-maximal intensity, with a pre-test rest period of two minutes. According to the procedure, the power grip was used, where the participants were asked to make the strongest and fastest possible grip trial holding the grip approximately 2 seconds. The HG test of the dominant and non-dominant hand was conducted twice (randomly) with a one-minute interval between different hand trials (Zarić et al., 2018; Dopsaj et al., 2019[b]). All the tests were performed in the Research laboratory

(MIL) at the Faculty of Sport and Physical Education (FSPE) University of Belgrade from 2017 to 2018 by the same investigator.

All the participants voluntarily took part in the study and the research was conducted according to the recommendations of the Declaration of Helsinki guidelines for physicians, for biomedical research involving human subjects (http://www.cirp.org/library/ethics/helsinki/), and with the ethical approval number 484-2 of the Ethics Committee of the FSPE, University of Belgrade.

Variables

Functional and mechanical characteristics of HG muscle force were measured in relation to the following dimensions:

1. the maximal (F_{max}) and relative muscle force (F_{rel});
2. the maximal (RFD_{max}) and relative explosive muscle force (RFD_{rel});
3. the time needed for achieving maximum force (tF_{max}) and maximal explosive ($tRFD_{max}$) muscle force;
4. the index of dimorphism (ID) for all muscle force, explosivity and time variables, as well as a specific index of synergy (SIS).

The variables for maximum and relative muscle force characteristics were:

1. Maximum muscle force for the non-dominant (F_{max}_ND) and dominant (F_{max}_D) HG, expressed in Newtons (N);
2. Relative muscle force for the non-dominant and dominant hand calculated as a summarized value of HG relative force (F_{rel}_SUM), expressed in Newtons per kilogram of body mass (N/kg).

The variables for maximum and relative explosive force characteristics:

1. Maximum explosive muscle force for the non-dominant (RFD_{max}_ND) and dominant (RFD_{max}_D) HG, expressed in Newtons per second (N/s);
2. Relative explosive muscle force for the non-dominant and dominant hand calculated as a summarized value of HG relative explosive force (RFD_{rel}_SUM), expressed in Newton per second per kilogram of body mass ($N/s \cdot kg^{-1}$).

The variables for maximum and explosive muscle force-time parameters:

1. The time needed for maximum muscle force production in the non-dominant (tF_{max}_ND) and dominant (tF_{max}_D) HG, expressed in seconds (s);
2. The time needed for maximum explosive muscle force production in the non-dominant ($tRFD_{max}$_ND) and dominant ($tRFD_{max}$_D) HG, expressed in seconds (s).

The variables for the assessment index of dimorphism (ID) and the specific index of synergy (SIS):

1. The Index of dimorphism for F_{max}, RFD_{max}, tF_{max} calculated as a relation between the mentioned characteristics of the non-dominant and dominant hand, expressed in percents (%);
2. The Specific index of synergy (SIS), calculated as a relation between F_{max} and RFD_{max}, expressed in arbitral units.

In this way, the functional and mechanical characteristics of the HG strength of the participants were described by twelve variables.

Statistical Analysis

First, all the raw data underwent descriptive statistical analyses in order for the basic values of central tendency and dispersion (Mean±SD) to be defined. The multiple and univariate analyses of variance (MANOVA and ANOVA) were used to calculate the differences between the subsamples with the Bonferroni Post Hoc test, as a criterion for the inter-group comparisons. All the differences were determined at the probability level of 95%, with a p-value set at level 0.05 (Hair, Anderson, Tatham, & Black, 1998). All the statistical analyses were carried out using the software package IBM SPSS Win Statistics 19.0.

RESULTS

Table 1 shows the results of the descriptive statistical analysis for all the tested participants and the variables. Table 2 shows the results of the MANOVA and ANOVA as the differences between the variables in the function of the examined groups. The results of the multiple analysis of variance prove that generally when it comes to the HG strength of the non-dominant (HG_ND) and the dominant hand (HG_D), as well as the summative values of the maximum force and maximum explosiveness (rel_SUM), there is a statistically significant difference between the young female handball players and the members of the control group, at a statistically significant level (Wilks′ Lambda Value=0.559, 0.573 and 0.190, p=0.000, 0.000 and 0.003, respectively). The only parameter that shows no statistical difference between the analysed variables is the dimorphism index (ID) (Wilks′ Lambda Value=0.092, p=0.332).

Table 1 Results of the descriptive statistics of the tested participants

	Sample	Handball		Control	
	Variables	ND	D	ND	D
Mechanical Characteristics	F_{max}	306.4±40.8	335.5±47.0	250.3±43.5	269.7±48.4
	RFD_{max}	1918.1±366.8	2174.8±382.1	1696.3±398.6	1868.0±415.6
	tF_{max}	0.774±0.330	0.698±0.230	0.539±0.215	0.554±0.215
	$tRFD_{max}$	0.131±0.019	0.128±0.018	0.127±0.016	0.123±0.019
	SIS	6.241±0.738	6.483±0.658	6.734±0.806	6.909±0.762
	F_{rel}_SUM	9.268±1.181		8.602±1.280	
	RFD_{rel}_SUM	58.919±8.628		58.587±10.323	
Functional Characteristics	ID_F_{max}	0.920±0.104		0.934±0.102	
	ID_RFD_{max}	0.889±0.134		0.910±0.109	
	ID_tF_{max}	1.179±0.462		1.042±0.383	
	ID_$tRFD_{max}$	0.968±0.118		0.980±0.115	
	ID_SIS	1.024±0.118		1.035±0.110	

Table 2 MANOVA and ANOVA results

	Effect	Multivariate Tests[c] Value	F	Hypothesis df	Error df	Sig.	Partial Eta^2	Observed Power
HG_ND	Wilks' Lambda	.559	10.108	5.00	64.00	.000	.441	1.000
HG_D	Wilks' Lambda	.573	9.534	5.00	64.00	.000	.427	1.000
ID	Wilks' Lambda	.092	1.174	5.00	64.00	.332	.084	.390
rel_SUM	Wilks' Lambda	.190	6.266	2.00	66.00	.003	.160	.882
		Tests of Between-Subjects Effects						
		Type III Sum^2	df	Mean Square	F	Sig.	Partial Eta^2	Observed Power
HG_ND	F_{max}_ND	54949.2	1	54949.2	30.94	.000	.313	1.000
	RFD_{max}_ND	859975.7	1	859975.7	5.88	.018	.080	.666
	tF_{max}_ND	.97	1	.97	12.35	.001	.154	.934
	SIS_ND	4.24	1	4.24	7.21	.009	.096	.754
	$tRFD_{max}$_ND	.00	1	.00	.80	.375	.012	.142
HG_D	F_{max}_D	75693.8	1	75693.8	33.27	.000	.328	1.000
	RFD_{max}_D	1645626.1	1	1645626.1	10.35	.002	.132	.887
	tF_{max}_D	.32	1	.32	6.40	.014	.086	.703
	SIS_D	3.17	1	3.17	6.29	.015	.085	.696
	$tRFD_{max}$_D	.00	1	.00	2.75	.102	.039	.373
HG_SUM	F_{rel}_SUM	7.63	1	7.63	5.05	.028	.070	.601
	RFD_{rel}_SUM	1.90	1	1.90	.02	.885	.000	.052

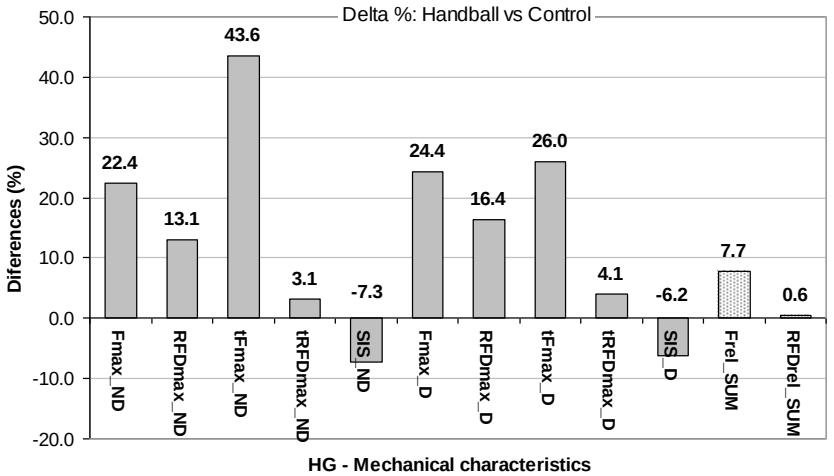

Fig. 1 Differences among the variables of the mechanical characteristics of the examined sub-specimens HG expressed as a percentage

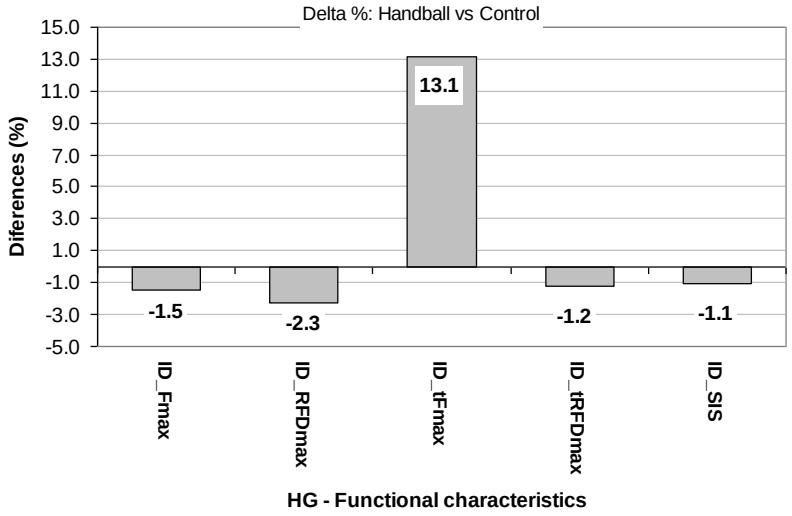

Fig. 2 Differences among the variables of the mechanical characteristics of the examined sub-specimens HG expressed as a percentage

Both figures 1 and 2 show the differences in mechanical and functional characteristics between the examined sub-specimens expressed as a percentage. The pairwise comparison results show that the levels of the statistically significant differences in the non-dominant hand vary from the highest in the F_{max}_ND (F=30.94, p=0.000, Partial η^2= 0.313, 22.4% difference) values to the lowest ones in the RFD_{max}_D (F=5.88, p=0.018, Partial η^2= 0.080, 13.1% difference), with only one variable, $tRFD_{max}$_ND, showing no difference between the sub-specimens (Table 2 and Figure 1). When it comes to the dominant hand, the levels of the statistically significant differences vary form the highest values, again, in the F_{max}_D (F=33.27, p=0.000, Partial η^2= 0.328, 24.4% difference) to the lowest values in the SIS_D (F=6.29, p=0.015, Partial η^2= 0.085, -6.2% difference), with the same variable showing no statistically significant difference between the two sub-specimens, $tRFD_{max}$_D, (Table 2 and Figure 1).

DISCUSSION

The results obtained show that the handball players who underwent the testing process achieved F_{max} at the levels from 306.4±40.8 to 335.5±47.0 N and RFD_{max} at the levels from 1918.1±366.8 to2174.4±382.1 N/s for the non-dominant and the dominant hand (Table 1). When compared to the control group, the young female handball players achieved a statistically significant higher level of the maximum HG force for both the non-dominant (F=30.94, p=0.000) and the dominant (F=33.27, p=0.000) hand, as well as a higher level of maximum explosiveness (F=5.88, p=0.018 and F=10.35, p=0.002, respectively) (Table 2). The achieved level of F_{max} is by 23.4% and the achieved level of RFD_{max} is by 14.8% higher than the control group levels, on average. It is also evident that the variable F_{max} had a span of influence between 31.3% and 32.8%, whereas the RFD_{max} had a span of influence

between 8.0% and 13.2% on the difference between the studied groups, respectively (Table 2). The previously discussed results point to the influence that the maximum HG level has on the difference between the studied young female handball players and the members of the control group, which is 3.02 times higher than the influence of the maximum explosiveness. The results also show that the influence of the F_{max} and RFD_{max} on the differences between the young female handball players and the members of the control group in the dominant hand variable is 14.6% higher than in the non-dominant hand variable. This difference can probably be ascribed to the cumulative influence that the handball training sessions had on the girls, as opposed to the members of the control group who did not have any sport or organized physical activity.

In previously published studies, it was shown that the HG levels of F_{max} and RFD_{max} in female judokas of the same age were from 240.8±64.7 to 241.8±47.6 N and from 1651.3±717.2 to 1633.0±554.3 N/s, for the left and the right hand, respectively (Marković et al., 2018[b]), while in female basketball players of the same age the given characteristics were at the following levels: from 286.2±41.7 to 302.0±48.7 N and from 2032.2±394.4 to 2182.2 ±458.0 N/s, for the left and the right hand, respectively (Zarić et al., 2018).

If these results are compared to the standard values of F_{max} and RFD_{max} for the young female population, which were determined to vary from 255.0±51.1 to 272.1±56.0 N and from 1624±354 to 1728±441 N/s for the non-dominant and the dominant hand respectively (Dopsaj et al., 2019[b]), it can be claimed that the level of the maximum HG force in handball players aged 16.6 is higher by 21.7%, and that the level of the maximum explosiveness during maximum HG is also higher by 22% than the results of the same variables in healthy girls aged 24.5.

The results obtained for F_{max} and RFD_{max} lead to the general conclusion that female handball players aged 16.6 have maximum HG force levels higher by 20-25%, and maximum HG explosiveness level higher by 15-20% than the same variables in the general population of adult girls (Dopsaj et al., 2019[b]). When compared to the results achieved by other female representatives of some different sport disciplines (judo and basketball), the differences vary from 10 to 30% for F_{max}, and from 0 to 25% for RFD_{max} (Markovic et al., 2018[b]; Zaric et al., 2018). When compared to the standards defined for female handball players aged 16, it can be concluded that the measured levels of F_{max} and RFD_{max} are in accordance with them (Dopsaj et al., 2019[a]). These facts only add up to the external validity of the current research.

If the numerical values of the F_{max} and RFD_{max} of the studied handball players are standardized in a point score by applying the mathematical model defined for the population of girls, it can be claimed that their F_{max} is at the development level of 68.29 points, whereas their RFD_{max} is at the development level of 67.02 points. In general, the sum of the HG contractile development is at the level of 68.98 points, which is higher than the average values for these particular mechanical characteristics (Dopsaj et al., 2019[a]).

The results of the time parameters show that there is no statistically significant difference, irrespective of the hand dominance, in the time needed for achieving the maximum intensity of the muscle excitation ($tRFD_{max}$) involved in the HG (flexor digitorum superficialis) between the female handball players and the members of the control group (Table 2). It can also be claimed that the aforementioned time variable is completely in accordance with the previously published results for the population of young females (Dopsaj et al., 2019[a]). However, when it comes to the time needed for achieving the

maximum HG force (tF_{max}), it was determined that the female handball players needed statistically significant more time than the members of the control group did, irrespective of hand dominance (34.8% more time, Figure 1; tF_{max} HG_ND, F=7.21, p=0.001, D = 6.40, p=0.014, Table 2). The reasons why the members of the control group who had never had training sessions needed statistically significant less time to achieve maximum HG force might lie in the following phenomenon: a certain degree of acute or chronic fatigue of the hand muscles responsible for the activity caused by everyday training sessions, including ball manipulation.

Although there is no statistically significant difference in the measured characteristics of the non-dominant and the dominant hand, i.e. the dimorphism index (ID) between the female handball players and the members of the control group, the established quantitative values are important for both sports science and practice (Table 1). The results show that the values of the dimorphism index in the female handball players are at the level of 0.920, and in the control group members at the level of 0.934, which implies that the level of the maximum force development of the non-dominant hand in the female handball players is at 92.0% of the dominant hand development, whereas the same difference in the control group members is at 93.4%. In other words, the bilateral deficit in the female handball players is at 8.0% and in the control group members at 6.6%. This deficit is higher in the RFD_{max} variable and reached the level of 11.1% and 9% for the female handball players and the control group members, respectively (Table 1). These results are completely in accordance with the previously defined standards of the functional dimorphism values set for top players, where the average asymmetry values of F_{max}ID are within the range from 0.8980 to 0.9287, which includes the results of the female handball players, and the symmetry values range from 0.9288 to 0.9594, which includes the results of the control group members (Ivanović & Dopsaj, 2012).

For the measured values of the ID time parameters (Table 1, ID_tF_{max} – Female handball players = 1.179 vs Control group = 1.042; ID_$tRFD_{max}$ – Female handball players=0.968 vs Control group=0.980), as well as for the specific synergy index (ID_SIS – Female handball players=1.024 vs Control group=1.035) there is no available data for comparison in the published literature, so they represent, from the standpoint of sport science, initial quantitative values.

CONCLUSIONS

The results obtained in this research show that the mechanical characteristics of the hand muscles, i.e. flexor digitorum superficialis of female handball players aged 16.6 on average (cadet-junior age) are more developed at a statistically significant level when compared to those of the members of the control group, young but physically inactive girls. It was established that in the studied female handball players the level of the maximum force ranged from 306.4±40.8 to 335.5±47.0 N and that the level of the maximum explosiveness ranged from - 1918.1±366.8 to 2174.8±382.1 N/s for the non-dominant and dominant hands, respectively. When compared to the general model of the given contractile properties, the levels of development of the measured HG characteristics were at 68.98 points, which is higher than the average values for the population of young girls. It was also shown that the tested time parameters of F_{max} and RFD_{max}, excitation, as well as the values of the dimorphism

index, were within the standard values, and that they were not very different from the values determined for the control group members. All the results prove that there is a positive adaptation from the aspect of the mechanical characteristics of the HG force, which is, most likely, the direct consequence of the biological adaptation to training stimuli specific to handball. However, the same influence was not established in the functional characteristics, that is, the tested dimorphism.

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MEHANIČKE I FUNKCIONALNE KARAKTERISTIKE SNAGE STISKA ŠAKE MLADIH RUKOMETAŠICA

Cilj ovog istraživanja bio je da se utvrde razlike u funkcionalnim i mehaničkim karakteristikama izometrijske snage stiska šake (SŠ) između mladih rukometašica i kontrolne grupe (KG) koju čine fizički aktivne devojke bez iskustva u sportu. U istraživanju je učestvovalo 70 ispitanika, od kojih je 36 najboljih mladih rukometašica (kadetske i juniorske kategorije), a 34 KG devojke. Dobijeni rezultati pokazuju da su mlade rukometašice koje su učestvovale u testovima postigle Fmax na nivoima od 306.4±40,8 do 335.5±47.0 N i RFDmax na nivoima od 1918.1±366.8 do 2174.4±382.1 N/s za nedominantnu i dominantnu šaku. Kada se ovi rezultati uporede sa rezultatima KG, jasno je da su mlade rukometašice imale statistički značajno viši nivo maksimalne snage SŠ obe šake, kao i viši nivo maksimalne eksplozivnosti. Nije bilo statistički značajne razlike između grupa u pogledu svih indeksa dimorfizma (ID), kao i u pogledu vremena potrebnog za postizanje maksimalnog intenziteta mišićne ekscitacije (tRFDmax). Na osnovu toga se može zaključiti da su rukometašice koje su prošle proces testiranja pokazale pozitivnu adaptaciju sa aspekta mehaničkih karakteristika snage stiska šake, što se najverovatnije može pripisati fenomenu biološke adaptacije na trenažne stimuluse karakteristične za rukomet. Nije međutim zapažen isti uticaj sa aspekta funkcionalnih karakteristika, tačnije dimorfizma.

Ključne reči: *rukomet, mehanička mišićna svojstva, test stiska šake*

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Research article

PERCEIVED AUTONOMY, THE MOTIVATION CLIMATE AND INTENTION FOR PHYSICAL ACTIVITY: A COMPARATIVE STUDY OF STUDENTS BASED ON THEIR GENDER AND EDUCATIONAL LEVEL

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Abstract. *The main aim of the present study was to examine whether perceived autonomy during physical education (PE) classes, the perceived motivation, and students' intentions for physical activity outside of school differ based on their educational level and gender. The sample consisted of 551 children (266 boys and 285 girls), of which 320 were attending primary school and 231 were attending high school. Four instruments were used for collecting data: (a) a demographics questionnaire; (b) the Perceived Autonomy Support in Physical Education scale (P.A.S. in PE) for assessing students' motivation; c) the Learning and Performance Orientations in Physical Education Classes Questionnaire (LAPOPECQ) for assessing the perceived motivational climate within the PE class, and (d) a questionnaire based on the Theory of Reasoned Action which assessed the participants' intentions for physical activity outside of school. The results showed that as children grow up and change educational levels, the perceived motivational climate with an emphasis on tasks, the sense of autonomy in PE, and the intention to exercise are on the decline. In addition, it appeared that girls exhibited less intention to exercise compared to boys, especially in the highest level of education, and were more likely to perceive the motivational climate in the PE lesson as task-oriented rather than ego-oriented. To sum up, the gender and educational level of students are considered two key factors for both motivation and a sense of autonomy in PE, as well as for their intention to exercise outside of school.*

Key words: *Motivational Climate, Perceived Autonomy, Physical Activity Intention, Educational Level, Gender*

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INTRODUCTION

Nowadays, it is well documented in the literature that the levels of students' internal motivation, as well as their willingness to participate in Physical Education (PE) classes decrease as they grow older and move from elementary to high school, with the tendency to decrease even further during the last years of high school (Harter, 1981; Papaioannou, 1997; Otis, Grouzet, & Pelletier, 2005; Pate, Schenkelberg, Dowda, & McIver, 2019). There is also a great concern about the number of children and adolescents adopting a sedentary lifestyle (Biddle, Sallis, & Cavill, 1998; Li et al., 2018), since inadequate activity not only has a direct adverse effect on children's health (Sallis, Patterson, Buono, & Nader, 1988), but also on their long-term health as adults (Sallis & McKenzie, 1991). However, as it has been shown in relevant studies (Shephard & Trudeau, 2000), an active post-adulthood lifestyle has its roots in adolescence, whereas PE can influence young people in their decisions about sports in the future (Coakley & White, 1992).

It is clear from the above mentioned, that in order to establish the importance of physical activity in everyone's consciousness, the corresponding habits for health and quality of life should be instilled from an early age (Sallis & Patrick, 1994; Telama, Yang, Laakso & Vilkari, 1997; Del Pozo-Cruz et al., 2019). It is for this reason that PE and the influence of the PE teacher play a key role in school life, not only in cultivating motor and cognitive skills, but also in improving the quality of students' life in the present as well as in the long term (Sallis & McKenzie, 1991; Wright, Patterson, & Cardinal, 2000). Towards this direction, supporting students' intentions and exploring all of the factors that may influence children's motivation and commitment to physical activity can act as a positive reinforcer (Taylor & Lonsdale, 2010).

One of the widespread psychological theories that examined and interpreted the factors responsible for manifestation and/or behavior change, is the so-called Theory of Reasoned Action-TRA (Ajzen & Fishbein, 1977; Breslin, 2018). According to the TRA, the appearance of a behavior depends on whether or not the individual is willing to manifest it. Intention, in turn, is predominantly determined by one's attitudes toward a certain behavior, where one's attitude represents the individual's overall assessment of his/her behavior (Ajzen, 1985) and by social role models and the perceived social pressure which guides an individual into adopting or rejecting a certain behavior (Dzewaltowski, Noble, & Shaw, 1990). It is important to notify that the evolution of TRA is the so-called Theory of Plan Behavior-TPB (Ajzen, 1988; 1991; Zhang, Gu, Keller, & Chen, 2019), which has been recognized as a highly effective theoretical framework for interpreting individuals' attitudes toward physical activity (Blue, 1995; Hausenblas, Carron, & Mack, 1997).

Further, one of the major theories for the study of motivation in education is the Self-Determination Theory - SDT developed by Deci and Ryan (1985), and developed worldwide, as it has been extensively studied and established experimentally from a multitude of researchers (Deci, Vallerand, Pelletier, & Ryan, 1991; Pelletier et al., 1995; Ivanović, Milosavljević, & Ivanović, 2017). Based on this theory, an attempt was made to determine the degree of motivation of a person, stemming from the individual himself/herself (internal motivation) rather than extrinsic factors (external motivation). This identifies how one feels about regulating their own behavior by themselves, and the more they feel they can regulate on their own, the higher their self-esteem is exhibited (Deci & Ryan, 1985). This theory highlights the social factors that a teacher needs to incorporate into his/her teaching style, in

order to satisfy three basic psychological needs of the students (Deci & Ryan, 1985; Ryan & Deci, 2008; Ryan & Deci, 2017). These psychological needs are: a) The internal need for autonomy, which refers to one's desire to act autonomously and to decide on one's own actions (Deci & Ryan, 1985; Ryan & Connell, 1989; Sun, Li, & Shen, 2017); b) the need for perceived competence – the ability that relates to one's desire to interact effectively with one's environment and to confirm one's abilities by demonstrating them (Deci, 1975; Harter, 1983; Koka & Sildala, 2018), that leads individuals to look for challenges which correspond to their abilities; and c) the need for good social relationships, which relates to trying to build positive relationships with other people in their environment, to care for them and to feel that they care for him/her too and to feel a sense of belonging with these individuals in a community (Baumeister & Leary, 1995; Hilland, Ridgers, Stratton, Knowles, & Fairclough, 2016).

A review of the relevant literature showed that although there is a relatively large amount of research on motivation and intention for physical activity, gender and age as parameters that could be related to these two variables (motivation, intention) were not investigated sufficiently.

Therefore, the main aim of the present study was to examine whether perceived autonomy during PE classes, the perceived motivation, and students' intentions for physical activity outside of school differ based on their educational level and gender.

METHODS

Participants

The study involved 551 students, aged 11 to 18 years (M=12.90±2.73 years), of whom 266 were boys (48.3%) and 285 girls (51.7%). The total sample consisted of 320 students (58.1%) attending the last two grades of elementary school and 231 students (41.9%) attending to the last three years of high school (Table 1).

Table 1 Baseline anthropometric characteristics of the participants

Sample Size		N	%
Educational Level	Primary School	320	58.1
	High School	231	41.9
Gender	Boys	266	48.3
	Girls	285	51.7
	Total	551	100

Design of the study

Purposive sampling was used to select the sample to ensure "special composition" in the sample groups. The anonymity of the students was ensured by using a code instead of the students' name. Questionnaires were completed in the classroom under the supervision of researchers and lasted 20 min. Initially, the students were informed about the procedure and how to complete the questionnaire. In the meantime, it was emphasized that participation in the research is voluntary, that the questionnaire is anonymous, that the children's responses will be kept confidential and that the resulting data will be used solely for the purpose of the research. The possibility of students leaving at any time they wish was also stressed and it

was clarified that this could be done without any requirement or other obligation on their part. Finally, it was explained that the purpose of the questionnaire was to improve the quality of the lesson rather than the students' grades and assessment.

Questionnaires

In this study, a total of 4 questionnaires were merged into one. More specifically, the measuring instruments were:

A questionnaire of demographics to gather information regarding gender, age and education level;

Perceived Autonomy Support in Physical Education - P.A.S. in PE (Hagger et al., 2007) for assessing students' motivation based on the theory of self-determination. Specifically, the PAS in PE consists of 12 closed-ended questions and participants are asked to answer on a 7-point Likert scale from 1 “strongly disagree” to 7 “strongly agree”. An example of a statement is "I can freely express to my PE teacher during the course". Validation and reliability testing in the Greek version were conducted by Hagger and colleagues (2007);

Learning and Performance Orientations in Physical Education Classes Questionnaire-LAPOPECQ (Papaioannou, 1994) on Climate Motivation Perception in the Physical Education Course. It is composed of 27 items and has two dimensions: Perception of motivational climate, which includes the task/learning climate (13 items) and Perception of motivational climate, which includes the ego/performance climate (13 items). Students had to answer on a 7-point Likert scale from 1 “strongly disagree” to 5 “strongly agree”. An example of a statement is "students fear failure in exercises because it would disapprove of others". The questionnaire has been developed and applied to the Greek school population by Papaioannou (1997);

Intention for Physical Activity: A questionnaire consisting of 3 questions was designed to assess the intention of students to exercise outside of school and was based on the theoretical background of the TRA and TPB. An example of a statement is "I plan to continue to train regularly for the next 6 months". Students had to answer on a 7-point Likert scale from 1 “strongly disagree” to 5 “strongly agree”.

The main hypotheses of the study

The main hypotheses of the study were: elementary school students compared to high school students would score higher on the perceived task-oriented motivational climate (hypothesis 1), as would girls compared to boys (hypothesis 2). High school students will perceive the motivational climate in PE more towards ego orientation rather than task orientation (hypothesis 3), as would boys compared to girls (hypothesis 4). Concerning perceived autonomy, elementary school students are expected to score higher on perceived autonomy than high school students (hypothesis 5). Finally, intention to exercise is expected to be higher in elementary school students than in high school students (hypothesis 6) with boys showing higher levels than girls (hypothesis 7).

Data analysis

To explore the role that independent research variables can play, namely the gender of pupils and their age/educational level, on the dependent one (i.e., perceived ego- or task-oriented perceptions of self-perception during the PE lesson, and intention to do physical activity outside of school) four two-way 2x2 ANOVAs were conducted. In all cases, the level of statistical significance was set at $p<.05$.

RESULTS

Descriptive Statistics

Descriptive statistics of the study's variables are shown in Table 2 and Table 3. The first impression given by the descriptive statistics on motivational orientation is that there appears to be a preference of elementary school students towards task orientation, i.e., TASKPRIMARY=4.29±.51 vs. TASKSECONDARY=3.63±.60 (Mean±SD). The reverse occurs regarding the ego orientation, i.e., TASKPRIMARY=2.55±.69 vs. TASKKSECONDARY=2.7±.62 (Mean±SD). On the other hand, in terms of gender, the difference is mainly in task orientation with an apparent superiority of girls, whereas in ego orientation boys show marginally higher values. Specifically, TASKGIRLS=4.08±.63 vs. TASKBOYS=3.94±.64 and EGOGIRLS=2.61±.65 vs. EGOBOYS=2.64±.67 (Mean±SD).

Table 2 Mean±SD results of task and ego orientation

	Task			Ego		
	N	Mean	SD	N	Mean	SD
Primary Education	312	4.29	.51	309	2.55	.69
Secondary Education	227	3.63	.60	223	2.72	.62
Boys	260	3.94	.64	255	2.64	.67
Girls	279	4.08	.63	277	2.61	.65

Corresponding to the perceived autonomy and intention to exercise, it seemed that students attending elementary school exhibited higher values for both variables, i.e., AUTONOMYPRIMARY=5.20±1.01 vs. AUTNONOMYSECONDARY=4.93±1.08 and INTENTIONPRIMARY=6.18±1.17 (Mean±SD). For the two genders the differences were smaller in absolute units with levels of perceived autonomy rising upwards for girls and levels of intent higher in boys, i.e., AUTONOMYGIRLS=5.15±1.08 vs. AUTNONOMYBOYS= 5.02±1.02 and 5.86=5.86 INTENTIONGIRLS=5.64±1.54 (Mean±SD).

Table 3 Mean±SD results of perceived autonomy and intention

	Perceived Autonomy			Intention		
	N	Mean	SD	N	Mean	SD
Primary Education	303	5.20	1.01	319	6.18	1.17
Secondary Education	225	4.93	1.08	230	5.15	1.58
Boys	256	5.02	1.02	264	5.86	1.33
Girls	272	5.15	1.08	285	5.64	1.54

Inferential Statistics

As far as the two-way ANOVA with a dependent variable task orientation and independent variables education, grade and gender is concerned, the results showed that elementary school students had significantly higher perceptions of the learning motivation climate than high school children [F (1.535)=189.18, p<.01, partial η2=.261]. Regarding gender, boys had significantly lower perceptions of the motivational learning climate than girls [F (1.535)=7.06, p<.01, partial η2=.013]. However, no significant interaction between the two independent variables (educational level, gender) was found [F (1.535)=.055, p=.81, partial η2=.00] (Hypotheses 1, 2). In other words, younger elementary school students and girls have higher levels of task orientation than high school students and boys, respectively. However, the interaction between gender and class had no effect on task orientation.

A similar ANOVA 2X2 analysis was conducted with ego orientation as the dependent variable. According to the results, elementary school students showed a statistically significant lower perception of motivational performance than high school students [F (1,528)=8.41, p<.01, partial η2=.016], whereas there is no statistically significant gender difference [F (1.528)=.265, p=.61, partial η2=.00] and no significant interaction between gender and educational level as well [F (1.528)=.060, p=.81, partial η2=.00] (Hypotheses 3, 4). Primary school students, therefore, were not as ego-oriented as high school students. However, there is no difference between girls and boys in both levels but also in connection with gender.

A two-way ANOVA 2×2 was also conducted with independent variables gender and educational level and with the dependent variable of perceived autonomy. The results showed that that elementary school students scored significantly higher in perceived autonomy values than high school students F (1.574=9.174, p<.01, partial η2=.017] (Hypothesis 5). It is important to underline that elementary school children also had higher rates of perceived autonomy.

Similar findings were shown with the analysis of Gender X Educational level (two-way ANOVA 2×2) with regard to Intention (Hypotheses 6, 7). However, the results in this case differ in their statistical significance. More specifically, a statistically significant difference was found in intention to educational level, with primary students exhibiting significantly higher levels of intention for physical activity than high school students [F (1.545) = 76.659, p <.01, partial η2=.123] but also regarding gender, with boys having significantly higher intentions for physical activity than girls [F (1.524)=6.029, p<.05, partial η2=.011]. Finally, the interaction between gender and educational level was also found to be statistically significant [F (1.524)=9.872, p<.01, partial η2=.018]. Elementary school students once again showed an increasing intention to exercise. The same thing happens this time with boys who seemed to choose to exercise more in their spare time than girls. The combination of gender and educational level plays an important role. Thus, elementary school students are expected to have much higher Intention to exercise rates than high school girls.

DISCUSSION

As it has been shown in previous studies, a) the psychological needs, stated in the Introduction, are positively related and are interconnected by an exercise and learning environment that enhances autonomy (Amorose & Anderson-Butcher, 2007), and b) a self-directed learning environment (even within a classroom) that is directed toward autonomy

reinforces motivation with high self-determination, as opposed to a more controlled-teacher-centered environment (Ryan & Deci, 2008). In addition, it should also be emphasized, the positive relationship of climate autonomy with perceived autonomy, perceived competence, and the relationships that develop among students (Cadorette, Blanchard, & Vallerand, 1996 as cited in Vallerand, 1997). This fact, combined with the findings of many studies that examined the impact of the autonomous climate on the pedagogical process on students' perceived competence (Trouilloud, Sarrazin, Bressoux, & Bois, 2006; Álvarez, López, Gómez, Brito & González, 2017), as well as on internal motivation (Deci, Nezlek, & Sheinman, 1981), on creativity (Koestner, Ryan, Bemieri, & Holt, 1984) and on school performance (Boggiano, Flink, Shields, Seelbach, & Barrett, 1993), but also in the lower likelihood of a student leaving school (Vallerand, Fortier, & Guay, 1997), indicates how important it is to support the climate of autonomy for PE teachers.

Furthermore, studies in the field of school PE (Vlachopoulosm Biddle, & Fox, 1996) have adopted the theory of goal achievement in order to examine the relationship between a person's achievement goals with pleasure and inner motivation from activity (Papaioannou & Theodorakis, 1996). According to that theory, the motivational climate in a classroom can be either task/learning oriented or ego/performance oriented. In the ego orientation (Nicholls, 1989), the criterion of success or failure is to compare one person's achievements to the norms, abilities or performance with those of others and their relevant ranking (Williams, 1994). Ego-oriented people try to bring about results with the minimum effort and feel at a disadvantage when they make mistakes (Dweck & Leggett, 1988), while after repeated failures they are likely to give up because they cannot feel successful by surpassing others (Papaioannou & Gouda, 1994). According to the work or task orientation (Nicholls, 1989), individuals set personal goals and try to improve their level of competence. Previous research has shown that there is a high positive relationship between task/learning orientation with interest and pleasure in activity, whereas ego/performance orientation is negatively correlated with pleasure and positively with high levels of cognitive anxiety, boredom and worry (Goudas, Biddle, & Fox, 1994).

Finally, the issue of learning performance and motivation was also examined in relation to gender, indicating differences between boys and girls, with girls taking the lead (van Langen, Bosker, & Dekkers, 2006). This differentiation could have been due to different degrees and/or different types of motivation between the two genders, since girls and boys set different goals and therefore approach learning differently. Thus, these different approaches can interpret the gender differences regarding school achievement (Steinmayr, Bipp, & Spinath, 2011). In this regard, a study by Dekker et al. (2013) examined whether gender could play a role in motive orientation. The results showed that girls were more likely than boys to support task/work-oriented goals (mastery goals) (48% vs. 39%) or to avoid ego/performance goals (performance-avoidant goals) (20% vs. 14%). It also appeared that boys often adopt task avoidance goals or ego-oriented goals. Also, the same survey found that at the age of 14-19, task avoidance orientation was twice as high in boys than in girls (27% vs. 12%). Finally, the results showed that with increasing age, mastery goals decreased (to 36%), while work avoidance goals increased (to 18%). These age and gender differences in goal orientations may be a possible explanation for the lower academic achievement of boys compared to girls and indicate the need for early intervention in the way that both genders are motivated.

The aim of the present study was to examine whether perceived autonomy in the PE class, the perceived motivational climate, and the students' intentions for physical activity outside school vary by their educational level and gender.

The findings of the present study showed that the initial assumptions were greatly satisfied which indicate a better understanding of the role of the motivational orientation and gender to the perceived autonomy and intention of elementary and high school students.

Specifically, with regard to the first two hypotheses, children in lower grades (primary education) as well as girls show higher levels of task orientation than high school students and boys respectively. That is, primary school students had a significantly higher perception of learning motivation climate than high school students, a result consistent with similar research in Greece (Papaioannou, 1997; Digelidis & Papaioannou, 1999).

Regarding gender, boys who exhibited significantly lower perceptions than girls' learning motivation climate confirm findings in the international literature that girls want to support task-oriented goals more than boys (Soini, 2006; Dekker et al., 2013; Grastén & Watt, 2016).

Correspondingly, hypotheses 3 and 4 were partially confirmed as it seems that primary school students are not as ego-oriented as high school children (Duda, 1996; Xiang, Lee, & Shen, 2001), which is not the case between girls and boys of both educational levels. In terms of ego-orientation, the only variable that seems to play a role is the age of children with students attending high school exhibiting higher levels.

Concerning hypothesis 5, primary school students showed significantly higher perceived autonomy than high school children, in accordance with what has been reported in previous studies (Levy, Polman, & Borkoles, 2008). This means that younger children are expected to show greater levels of perceived autonomy despite being boys or girls. This finding is also in line with past literature (Lim & Wang, 2009). The linear negative relationship between age and perceived competence in childhood and adolescence has also been highlighted by Gillet, Vallerand, and Lafrenière (2012) and Cheval, Courvoisier, and Chanal (2016).

Finally, regarding hypotheses 6 and 7, it was found that elementary school students were more likely to exercise in their spare time. This was foreseen by the relevant literature review (Sallis, Prochaska, & Taylor, 2000). The same holds true for boys more than girls as well as the interaction between gender and educational level. Thus, boys in the lower grades of primary school show a higher intention than girls in the last years of high school.

CONCLUSION

Summarizing the above mentioned results, it can be assumed that elementary and high school students supported by a climate of learning motivation by their immediate family and/or learning environment are more likely to exhibit higher perceived autonomy and thus an intention to exercise. Due to the fact that girls seem to be much more impressionable by the environment, boys may need to be immersed in a task-oriented motivational climate with work-oriented goals rather than performance. However, it should not be overlooked that girls show less intention to exercise than boys, at least in the secondary level of education. It would be interesting to have a longitudinal study examining whether girls' high motivation for learning influences their intention to exercise in adulthood. It can also be concluded that the higher the students' age and educational level, the lower learning motivation orientation

and exercise intention they get. Summarizing, parents and teachers are more likely to provide children with less and less autonomy over time, feeling that their children may no longer need it as they grow up and can more easily self-regulate without adult support. Although, another possible scenario for this downward path of perceived autonomy could be due to the mismatch between the expected autonomy that children want to receive over time and the autonomy they actually receive.

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OPAŽENA AUTONOMIJA, MOTIVACIONA KLIMA I INTENCIJA PREMA FIZIČKOJ AKTIVNOST: UPOREDNO ISTRAŽIVAWE STUDENATA NA OSNOVU POLA I NIVOA OBRAZOVANJA

Glavni cilj ovog istraživanja bio je da se ispita da li se opažena autonomija tokom nastave fizičkog vaspitanja (FV), opažena motivacija i namere učenika prema fizičkim aktivnostima izvan škole razlikuju u skladu sa njihovim obrazovnim nivoom i polom. Uzorak se sastojao od 551 dece (266 dečaka i 285 devojčica), od kojih je 320 išlo u osnovnu školu, a 231 u srednju. Za prikupljanje podataka korišćena su četiri instrumenta: (a) demografski upitnik; (b) skala opažene autonomije u fizičkom vaspitanju (prema engl. Perceived Autonomy Support-P.A.S. u FV) za ocenjivanje motivacije učenika; c) Upitnik za ocenu opažene motivacione klime u okviru nastave fizičkog vaspitanja (prema engl. Learning and Performance Orientations in Physical Education Classes Questionnaire-LAPOPECQ) i (d) upitnik zasnovan na Teoriji razumnog delovanja kojim su ocenjivane intencije učesnika ka fizičkom aktivnošću van škola. Rezultati su pokazali da kako deca odrastaju i menjaju obrazovni nivo, opažena motivaciona klima sa naglaskom na zadatak, osećaj autonomije u FV i namera za vežbanjem opadaju. Pored toga, činilo se da devojčice pokazuju manju nameru da vežbaju u poređenju sa dečacima, posebno u najvišem stepenu obrazovanja, i više verovatno doživljavaju motivacionu klimu na časovima FV kao orijentisanu na zadatak, a ne na ego. Ukratko, pol i obrazovni nivo učenika smatraju se kao dva ključna faktora za motivaciju i osećaj autonomije u obrazovanju, kao i za njihovu nameru da vežbaju van škole.

Ključne reči: *motivaciona klima, opažena autonomija, namera fizičke aktivnosti, obrazovni nivo, pol*

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Review article

DOES THE FEMALE ATHLETE TRIAD REALLY EXIST?

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Abstract. *The Female Athlete Triad (Triad) is a medical condition of female athletes consisting of three components: low energy availability (EA), menstrual dysfunction (MD), and low bone mineral density (BMD). The prevalence of all three components of the Triad ranges from 1-14%. In last ten years, it has ranged from 1.3% up to 23% with 78% of female athletes having at least one of the three components of the Triad. The aim of this systematic review is to collect and analyze recent studies of the Female Athlete Triad. Based on an analysis of electronic databases and the inclusion criteria set, 20 studies were included in the analysis. The following conclusions are proposed based on their analysis: MD was the most prevalent among endurance athletes with ranges from 35.5% to 60.7%, with the presence of secondary amenorrhea and oligomenorrhea, 30% to 64.0% and 18% to 27.0% and with a very high level of cases with irregular menorrhea, 72.3%. Low/negative EA ranges from 19.8% among non-leanness athletes and up to 77%. The greatest proportion of athletes in moderate- and high-risk categories for expressing the Triad participated in sports that emphasize leanness, including cross-country, gymnastics running, and lacrosse. A recommendation for future research is that they should focus on enhanced monitoring of physically active women, and the prevention of the Triad, stress fractures and osteoporosis.*

Key words: *Female Athlete Triad, Stress Fracture, Energy Availability, Menstrual Disorders, Amenorrhea, Bone Mineral Density*

INTRODUCTION

The Female Athlete Triad (Triad) is a medical condition of female athletes consisting of three components: low energy availability (EA) with or without disordered eating, menstrual dysfunction, and low bone mineral density-BMD (Nattiv et al., 2007; de Souza et al., 2014; Joy et al., 2014). This problem was first recognized and defined as the Triad

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in 1992 by the American College of Sport Medicine (Nattiv, Agostini, Yeager, & Drinkwater, 1993; Yeager, Agostini, Nattiv, & Drinkwater, 1993). In 2014, the ACSM constructed the Coalition guidelines for determining the level of risk for the Triad (de Souza et al., 2014). Despite that, the fact that the presence of all the components of the triad is still present at a high level among women is devastating. The prevalence of all three components of the Triad ranges from 1-14%. In last ten years, it has ranged from 1.3% (Schtscherbyna, Soares, de Oliveira, & Ribeiro, 2009), 3.3% (Micklesfield, Hugo, Johnson, Noakes, & Lambert, 2007), 5.4% (Movaseghi et al., 2012) up to 23% (Hoch et al., 2011; Melin et al., 2015), with 78% of female athletes having at least one of the three components of the Triad (Bubanj & Obradović, 2002; Cobb et al., 2003; Torstveit & Sundgot-Borgen, 2005; Beals & Hill, 2006; Nichols, Rauh, Lawson, & Barkai, 2006; Schtscherbyna et al., 2009; Hoch et al., 2009; Hoch et al., 2011).

Of the three components, menstrual dysfunction (MD) has exhibited the strongest relationship to injury, showing positive associations with increased risk of stress fractures (SF) among collegiate athletes (Myburgh, Hutchins, Fataar, Hough, & Noakes, 1990; Kelsey et al., 2007), competitive club track-and-field athletes (Bennell & Crossley, 1996; Beachy, Akau, Martinson, & Olderr, 1997), adult recreational runners or athletes (Kelsey et al., 2007; Nattiv et al., 2007) and military recruit populations (Henriksson, Schnell, & Hirschberg, 2000; Austin, Reinking, & Hayes, 2009). MD is common among female athletes, but is often ignored and regarded as a natural result of intense training, despite the fact that negative health consequences exist (Nattiv et al., 2007).

One of the primary causes for developing MD is reduced EA, actually low EA, which is the product of high intensity training and disordered eating (DE), or its associated conditions. Low EA brings a short luteal phase defect (LPD) in females with eumenorrhea and with oligomenorrhea/functional hypothalamic amenorrhea (FHA), which further turns good bone health into low BMD that can lead to injuries, loss of competition, and early onset of osteoporosis with Z-score <-2 (Nattiv et al., 2007). Everything mentioned is usually followed with secondary risk factors for stress fractures (SF) (Bachrach, 2001; Weaver, 2002; Nichols et al., 2006; Nattiv et al., 2007; Baxter-Jones, Faulkner, Forwood, Mirwald, & Bailey, 2011). Some other studies state the theory that SF are common overuse injuries among athletes (Bennell & Brunker, 2005) and related to a sudden increase in training (Sullivan, Warren, Pavlov, & Kelman, 1984) and that the components of the Triad play a minor role in the development of SF (Cosman et al., 2013).

Based on the above mentioned, the aim of this paper is to analyze recent research that examined the existence of the Triad and try to answer the question if it really exists.

METHODS

Research strategy

For the collection of relevant research papers, the following electronic databases were used: *DOAJ*, *PEDro* and *PubMed*. For the purpose of closer search and selection of research papers, the search was limited to using key words that are related to the problem of this research: the female athlete triad, stress fracture, eating disorder, disordered eating, menstrual dysfunctions, amenorrhea, bone density.

Selection strategy

The final analysis includes all available studies published during the last 10 years, namely between 2010 and 2019, which determined the relationship between the components of the Female Athlete Triad.

Inclusion criteria

The review included journal articles written in English and published during the last 10 years. To be included in the analysis, the articles were required to include the existence of some of the components related to FAT: menstrual dysfunction, low energy availability and physical intensity.

Exclusion criteria

The exclusion criteria were as follows: (1) studies without any of the Triad components; (2) studies without female samples and (3) studies written in languages other than English.

Data analysis

Table 1 provides an overview of close analyses of 20 studies that met the set criteria. Following the conventions for systematic reviews, the table presents the following parameters: reference, population group, sample of participants (gender, number and age), body composition parameters (body mass index - BMI, percentage of body fat - %BF, lean body mass - LBM), health status (menarche age, year cycles, menstrual irregularity, bone stress injury) and weekly training frequency, the results and conclusion.

Table 1 Summary of characteristics of all studies meeting the inclusion criteria

Ref.	Population group	Sample (gender, number and age)	BMI (kg/m^2), BF (%), LBM (kcal/kg/LBM), T (h/week)	Health status (Menarche age (year); year cycles, menstrual irregularity, bone stress injury (%))	Results (M±SD)	Conclusion
Yang et al. (2010)	Secondary school dancers (E); secondary school healthy controls (C).	F: 133 (E: 60, C: 77); Y: (E) 16.5±0.7; (C) 16.4±0.6	BMI: (E) 18.3±1.4; (C) 21.7±3.1; BF: (E) 25.0±0.5; (C) 34.0±0.4 T (h/w): E: 26.5±5.2; C: /	MA: (E) 14.0±0.9; (C) 13.0±1.3 MI: SA: (E) 26.5%; (C) 14.3%; PA: (E) 19.0%; (C) 0%; IM: (E) 72.3%, (C) 27.3%	BMI, MA, PA, MI dancers ↑($p<.05$); SA dancers ↑($p<.01$) %BF controls ↑($p<.01$) BMD at total body and legs dancers ↑($p<.05$); BMC ↑($p<.01$)	Bone mass status is a combined result of nutritional status, intensive exercise, menstrual irregularity and systemic hormone decrease. Disordered eating, especially low energy intake, might be the pivotal negative factor of the Triad.
Rauh et al. (2010)	High school competitive athletes	F: 163 (I: 61, U: 102); Y: 15.7±1.3 I, injured; U, uninjured.	BMI: (I) 21.4±2.6; (U) 21.8±2.9 BF: (I) 26.0±6.1; (U) 26.3±7.3 LBM: (I) 39.7±4.6; (U) 39.7±4.7	MA: (I) 12.6±1.2; (U) 12.6±1.2 YC: (I) 10.9±2.1; (U) 11.0±2.4	MA with O/A older than normal menses ($p<.001$) Injured had ↓ score BMD spine ($p=.03$), BMD z score spine ($p=.02$) and BMD total body ($p=.05$) O/A ↑ injuries ($p=.004$) DE ↑ injuries ($p=.04$) or dietary restraint behavior ($p=.04$)	Disorder eating, oligomenorrhea/amenorrhea, and low BMD were associated with musculoskeletal injuries.

Hoch et al. (2011)	Professional ballet dancers	F: 22 Y: 23.2±4.7	BMI: 19.29±1.1; BF: 16.7±4.9	MA: 13.6±1.8 MI: SA: 64.0%, (C) 14.3%; PA: 18.0%; O: 27.0%	77% with low/negative EA 32% EDE-Q scores>4.0 23% sig. ↓ One (36%), two (14%) three (23%) or four (14%) of the triad components (p<.05)	Prevalence of the 4 components (triad and reduced endothelial function) was correlated with reduced BMD and is high in professional dancers.
Movasegh i et al. (2012)	Elite female athletes and athletes on national teams	F: 786 Y: 21.1±4.5	BMI: Low-risk sports: 21.2±2.9; High-risk sports: 20.6±1.5 T (h/w): Low-risk sports: 12.7±10.7; High-risk sports: 14.8±10.4	MA: 13.7±1.6 MI: Total population: 9.2%; Low-risk Sports: 7.7%; High-risk Sports: 11.7% BSI: 2% (Low-risk sports: 6; High-risk sports: 11)	One (58.9%), two (35.7%) or three (5.4%) of the triad components (p<.05)	Athletes in the high-risk group had significantly more stress fractures than those in the low-risk group.
Cosman et al. (2013)	Athletes and military recruits	N: 891 (M: 755, F: 136); Y: (M) 18.7; (F) 18.4	BMI: Mw/SFvsNoSF: 24±4 vs 25±3; Fw/SFvsNoSF: 23±3 vs 23±2 BF: Mw/SFvsNoSF: 9±3 vs 9±3; Fw/SFvsNoSF: 20±3 vs 21±3 SF, stress fracture, NoSF, no stress fracture T (h/w): Mw/SFvsNoSF: <7 (19±44 vs 173±24) ≥7 (24±56 vs 536±75); Fw/SFvsNoSF: <7 (7±27 vs 23±22) ≥7 (19 ± 73 vs 85±78)	MA: Fw/SFvsNoSF: 4.9±1.2 vs 5.8±1.4 YC: Fw/SFvsNoSF: 0-6 cycles/% 1±4 vs 12±12; 7-9 cycles/% 4±16 vs 12±12; 10-12 cycles/% 21±80 vs 82±76 BSI: Prior fracture (%): Mw/SFvsNoSF: 16±37 vs 353±50; Fw/SFvsNoSF: 8 ± 31 vs 47±44 History of prior fracture: Mw/SFvsNoSF: 13±30 vs 158±22; Fw/SFvsNoSF: 5±19 vs 12±11	More than 50% of the stress fracture occurred within the first 3 months of matriculation to the USMA 58% of cases were metatarsal fractures and 29% tibia fractures Mean age in Fw/SF sig. ↓ vs Fw/NoSF Males who exercised less than 7 h/w the year before entering the academy (44% w/SF vs 24% w/NoSF) (p<.004) F w/SF later had MA (p<.01)	Intrinsic factors (physical training in men, length of prior estrogen exposure in women and leg bone dimensions in both genders) play a little role in affecting the risk of stress fracture (explaining less than 10% of the risk).
Barrack et al. (2014)	Cohort study in exercising women with menstrual disturbances (E) vs exercising women with regular ovulatory menstrual cycles (C)	F: 259 (BSI: 28; NI: 231) Y: 18.1±0.3 (BSI: 17.5±0.6; NI: 18.2±0.3) BSI, bone stress Injury; NI, not injured	BMI: 21.5±0.2 (BSI vs NI: 20.7±0.4 vs 22.6±0.2) BF: 25.4±0.4 (BSI vs NI: 22.6±1.4 vs 25.8±0.4) LBM (kg): 40.6±0.3 (BSI vs NI: 41.2±0.9 vs 40.5±0.3) T (h/w): ≥12 h/w 65.6 (BSI vs NI: 89.3 vs 62.8)	MA: 12.8±0.1 (BSI vs NI: 12.7±0.3 vs 12.8±0.1) MI: O/A: 35.5 (BSI vs NI: 35.7 vs 35.5) BSI: 10.8% (tibia: 67.9%, metatarsals: 14.3%, femur: 7.1%, sesamoid: 7.1%, sacrum: 3.6%)	Sport development of SF: Endurance running 64.3%; Track and field 32.1%; Dance 3.6%. Participants w ↑%SF exercised ≥12 h/w, exhibited BMI<21.0 kg/m² and had BMD Z scores <-1.0 and ≤-2.0.	The study observed a sig. relationship between those meeting criteria for an increasing number of Triad-related risk factor variables and the development of prospective bone stress injuries. Single and combined risk factor variables exhibiting the strongest association with injury incidence included elevated exercise training and low BMD (Z score <.1.0). The risk of BSIs increased from approximately 15% to 20% for a significant single risk factor to 30% to 50% for sig. combined female athlete triad-related risk factor variables.

Brown et al. (2014)	High school athletes	F: 240 Y: 14±18	BMI: 20.88±2.7	MA: 12.86±1.29 MI: 152 (No achieved menarche: 12; SA: 1, w/history 39; PA: 4) BSI: 17%	Girls who had reached menarche in ≥ previous 2 years had 3.96 times higher odds of having MI than girls with more recent menarche (p=.014) 42% of athletes had 2 or more of the risk factors: history of amenorrhea and stress fracture, self-reported insufficient eating, underweight, pressure to be a certain weight and wanting to lose >10 pounds.	Menstrual irregularity and stress fracture incidence were relatively common among this population of female high school athletes.
Rauh et al. (2014)	Interscholastic cross-country and track runners	F: 89 Y: 15.5±1.3	BMI: 21.6±2.7 BF: 26.0±6.8 (BSI vs NI: 26.7±6.2 vs 25.5±7.2 LBM (kg): 38.9±4.3	MA: 12.3±1.1 MI: 21.3% YC: 10.9±2.3 (BSI vs NI: 11.1±2.0 vs 10.8±2.5) BSI: 42.7%* (shin/calf 46.2%; knee 15.4%; hip 15.4%; foot 12.3%) *musculoskeletal injuries	O/A runners had older MA than normal menses (p=.001) Injured runners had ↓BMD of the spine (p=.009), total hip (p=.03), and whole-body (p=.04) O/A correlated sig. with ↑ musculoskeletal injury occurrence	Oligo/amenorrhea and low BMD were associated with musculoskeletal injuries among female interscholastic cross-country and track runners.
Ackerman et al. (2015)	Runners and weight-bearing aerobic activity	F: 175 (O: 100; E: 35 & Non-athletes: 40) Y: 14–25	BMI: 20.4±2.3 (O); 22±2.3 (E); 22±2.3 (Non-athletes) T (h/w): 20	MA: 13.8±1.9 (O); 12.5±1.5 (E); 12.4±1.2 (Non-athletes) BSI: 47 % (O); 25.7 % (E); 12.5 %(Non-athletes)	BMD Z-scores were lower in AA ($p \leq 0.001$) In AA, those who had 2 stress fractures had lower BMD Z scores ($p \leq 0.05$)	Weight-bearing athletic activity increases BMD, but may increase stress fracture risk in those with menstrual dysfunction.
Duckham et al. (2015)	Endurance athletes	F: 70 (61, 9 withdrew) Y: 25.3±7.3	BMI: 19.8±1.5 BF: 17.0±5.1 T (h/w): Case 1: 9.5; Case 2: 19.5; Nl: 12.5±1.3	MA: 14.0±0.2 MI: Current O/A: 47.5%; History A: 60.7 BSI: 17±28.8; Injured over last 12 months: 2 (Case1 and Case2)	%BF ↓ in Case 1 and Case 2 than the group. Case 1 was smaller and lighter than the controls, with ↑ EI and low EPS Case 2 had a late age at menarche (16yr), ↑ BMI and ↓ EI	These findings could not be explained by awareness of Triads; there was a high prevalence of menstrual dysfunction, which could reflect changes in athlete behavior or training practices.
Melin et al. (2015)	Elite endurance athletes	F: 40 Y: 26.3±5.7	BMI: 20.5±1.9 BF: 11.9±3.2 T (h/w): 11.4±4.5	MI: 60% (O: 6; SA: 14, w/history 39; PA: 4) BSI: 17.2% (45% impaired bone health)	63% had low/reduced EA, 25% ED. Low EA group ↑ WF than optimal EA (p=.06) 25% w/O had DE/ED and 67% had low/reduced current EA. 67% w/impaired bone health had O, 33% had DE/ED One (35%), two (32%) or three (23%) of the triad components	Athletes with low/reduced EA and/or MD had lowered RMR. Triad-associated conditions were common in this group of athletes, despite a normal BMI range.
Tenforde et al. (2015)	Runners	G: F: 94; M: 42 Y: 16.9±1.3 (F); 16.3±1.3 (M)	BMI: 20.4±2.4 (F); 20.1±2.0 (M) FM: 14.2±5.2 (F); 8.8±3.4 (M) T (km/w): 27.4 ± 19.2	MA: 12.9±1.5 MI: Current O/A: 35%; History A: 43% BSI: Low bone mass: 14% (F), 21% (M)	Current MI & BSI: (all P<.01) MAage, low lean mass & Z-score (p<.01) <17.5 kg/m^2 & MI ↓ Low bone mass; SF: 24%	Both female and male adolescent runners are at risk for impaired BMD
Nieves et al. (2016)	Elite military cadets	F: 91 Y: 18.4±0.8	BMI: 22.8±2.2 BF: 20.9±3.0	MA: Years from 5.6±1.4 YC: (10-12 cycles) 66; (0-9 cycles) 25	50% of the women had bone loss in at least one: the spine, hip, calcaneus. Bone loss occurred at the spine and hip in those with menstrual dysfunction (p<.05) Hip and calcaneus BMD ↓ with weight loss (p<.05)	Risk factors including subclinical eating disorders, weight loss and menstrual dysfunction can have sig. detrimental effects on BMD in young healthy physically active women.

Prather et al. (2016)	Elite female soccer athletes	F: 220 (34% grade/middle school; 36.8% high school; 12.7% collegiate; 16.3% professional) Y: 16.4±4	BMI: 20.8±2 T (h/w): 9.5±6	MA: 13.0±1.0 (64% not yet reached menarche) MI: 19.3% (19% High school, 17.9% collegiate, 19.4% professional) BSI: 8.6% (19SF of the lower extremity)	8.1% were considered at risk for an eating disorder Athletes w EAT-26 score ≥10 points had a significantly higher prevalence of MI (p=.02) Two of the athletes w EAT-26 score ≥10 had a history of lower extremity SF.	Elite female soccer athletes are susceptible to stress fractures and menstrual dysfunction and have delayed onset of menarche despite normal BMI and appropriate body perception and attitudes towards eating.
Thralls et al. (2016)	High school athletes	F: 320 (70% endurance runners) Y: 15.9±1.2	BMI: 21.1±2.7 BF: 24.6±6.9 LBM (kg): 39.5±4.4	MI: 30% YC: 10.2±3.2	Dietary restriction (DR) 10.9% IBW ≤85% were nearly 4 times more likely to report MI and had low BMD <5th percentile BMI were 9 times more likely to report MI and had low BMD Athletes w/ ↑ %BF were almost 3 times more likely to report DR	Low age-adjusted BMI and low IBW may serve as evidence-based clinical indicators that may be practically evaluated in the field, predicting MI and low BMD in adolescents.
Tenforde et al. (2017)	University athletes	F: 323 Y: 20.0±1.3	BMI: 22.9±2.7	MA: delayed 11.8% (15-<16y); 10.8% (≥16y) MI: O: 11.1%; A: 8.7 BSI: 15.8%	Gymnastics, lacrosse and cross-country athletes were moderate- or high-risk ↓BMI and ↑BSI cross-country runners: 22.9% had a history of delayed menarche and the majority of athletes with delayed menarche were lean-sport athletes O/A and SF were independent predictors for subsequently sustained BSI	29% of female collegiate athletes in this study were classified as moderate- or high-risk categories using the Triad Cumulative Risk Assessment Score. Moderate- and high-risk athletes were more likely to subsequently sustain a BSI.
Tenforde et al. (2018)	Collegiate sports	F: 239 Y: 19.9±1.2	BMI: 22.9±2.8 BF: 24.9±5.8	/	BMD Z-score↓: Synchronized swimming, swimming/diving; crew 7 rowing, cross country. Triad risk factors associated/BMD Z-score (p<.05) BMI associated/ oligomenorrhea/amenorrhea (p<.05)	Athletes with low BMI and oligomenorrhea/amenorrhea are at the highest risk for reduced BMD
Clark et al. (2018)	NCAA Division I Student-Athletes	F: 15 Y: 19-22	Clinical vs. reported MD BMI: 20.5±1.6; 20.9±2.0 BF: 19.6±2.5 19.8±5.3	MI: 40% current; 53% history (A: 60%) BSI: 33% (clinical MD); 11% (reported MD)	MD: 40% EA↓: 53% MD→EA↑	The association between menstrual function and low energy is big; menstrual status was not associated with dyslipidemia.
Brook et al. (2019)	Elite para athletes	G: F: 110; M: 150 Y: 31.7±11.5	BMI: ≤17.5 (4.3%); 7.6-18.4 (3.1)	MA:.9% (<16y); 5% (≥16y) MI: O: 24%; A: 20% BSI: 5% (1 bone stress); 4.2% (2 bone stress); Low BMD: 8.5%	ED: 3.1%	Factors associated with the Triad are present in an elite para athlete population, regardless of sex or sport type.
Tosi et al. (2019)	Figure skaters (FS), dancers (D), and runners (R)	F: 712 (FS: 60%; D: 28%; R: 12%) Y: ≤17 (78%), 18-25 (22%)	BMI: /	MI: O: 25% BSI: 34%	Knowledge of the Triad (HN): 7% Young adults vs. adolescents: R=1.88 (p<.05) D vs. FS: R=0.43 (p<.001) D vs. R: R=0.49 (p<.05) HN: R = 2.43=.05 (p<.05)	Most athletes were at risk of the Triad but few knew about it. Dancers were at a higher risk compared to figure skaters and runners.

Legend: M – male; F – female; Y – age; BMI – body mass index; %BF – percentage of the body fat; LBM – lean body mass; MA – menarche age; YC – year cycles; MI – menstrual irregularity; BSI – bone stress injury; SF – sessions frequency; WF – weekly frequency; TD – training duration; TY – training years; AN – anorexia nervosa; BN – bulimia nervosa; ED – eating disorders; A – amenorrhea; SA – secondary amenorrhea; PA – primary amenorrhea; O – oligomenorrhea; E – eumenorrhea; PCOS – oligomenorrhea including polycystic ovary syndrome; IM, irregular menorrhea; EPS, eating psychopathology score, EI, energy intake; IBW – ideal body weight; RMR – low resting metabolic rate; ↑- high; ↓ - low.

RESULTS

Database searches returned 243 studies. After eliminating all duplicate articles, analyzing titles and screening abstracts, 37 studies entered the next stage of analysis. Only the studies that had included relevant outcomes were considered. The final number of studies included in the analysis was 20.

All the studies that met the inclusion criteria were published in the English language between 2010 and 2019. The pooled sample size of the 20 studies is 5184, whereas a typical size of individual studies ranged from 15 in the research of Clark, Dellogono, Mangano & Wilson (2018) to 891 participants per group in the research of Cosman et al. (2013). The first study in this group was published in 2010 (Yang et al., 2010), and the last in 2019 (Tosi, Maslyanskaya, Dodson, & Coupey, 2019). The participants mostly belonged to the age group 14±18 in the research Brown, Wengreen, & Beals (2014) to 31.7±11.5 year-old participants in the research of Brook et al. (2019). Genderwise, females were the most represented group, with 17 studies including only female participants and three including both sexes (Cosman et al., 2013; Tenforde, Fredericson, Sayres, Cutti & Sainani, 2015; Brook et al., 2019). All the participants belonged to a healthy and active group of people, all of which took part in some sport activities, recreational, national or professional (Hoch et al., 2011; Movaseghi et al., 2012; Ackerman et al., 2015; Melin et al., 2015; Prather et al., 2016; Brook et al., 2019), competitive (Barrack et al., 2014), high school and collegiate athletes (Yang et al., 2010; Rauh, Nichols, & Barrack, 2010; Brown et al., 2014; Rauh, Barrack, & Nichols, 2014; Thralls, Nichols, Barrack, Kern, & Rauh, 2016; Tenforde et al., 2017; Tenforde et al., 2018) and military organization athletes (Cosman et al., 2013; Nieves et al., 2016) in the following sports: endurance running (Rauh et al., 2014; Duckham, Brooke-Wavell, Summers, Cameron, & Peirce, 2015; Melin et al., 2015), dance (Yang et al., 2010; Hoch et al., 2011; Tosi et al., 2019), soccer (Prather et al., 2016). The amount of BMI ranges from ≤17.5 in the study Brook et al. (2019) to 25±3 in the study Cosman et al. (2013).

DISCUSSION

The number of physically active women has grown over the years and they are involved in various types of sports activities, recreational and professional. Under the influence of the environment, ambitions, expectations, they are expected to achieve better results in competitions, look better, and have a lower percentage of body fat. Since 1992 (Nattiv et al., 1993), the number of cases exhibiting the Triad has not diminished. Tenforde et al. (2017) in their research using the 2014 Female Athlete Triad Coalition guidelines (de Souza et al., 2014) identified that 29% of athletes were classified as having moderate or high risk of having all three of the components of the Triad. Those athletes belonging to the higher risk categories had a significantly increased risk of sustaining a subsequent SF. In the research Melin et al. (2015), 50% of cases had one of the conditions of the Triad, 25% two and one had all three components, while in the research of Rauh et al. (2014) there were 23% cases with a history of all three components, with one (35%), two (32%) and three (23%) components. Brown et al. (2014) presented 5.4% cases with three, 35.7% two and 58.9% one of the components, which has drastically increased compared to previous years where in 2008, Torstveit,

Rosenvinge, and Sundgot-Borgen presented 2.3% having all three components among long distance running athletes (3.3% among ultra-marathons and 1.5% among half-marathoners), two 21% and 12%, one 40% and 50% respectively. In the research of Micklesfield et al. (2007) 23% cases of elite dancers had all three components, 14% two, 36% one and 14% met the criteria for all three components and reduced MD. The greatest proportion of athletes in the moderate- and high-risk categories for expressing FAT took part in sports emphasizing leanness, including cross-country, gymnastics, and lacrosse (Tenforde et al., 2017), while ultra-marathoners are at a higher risk than half-marathoners (Micklesfield et al., 2007).

The first component of the Triad, where the effect of unbalanced nutrition and exercise is reflected, is MD. MD is mostly affected by energy deficiency (DE), low EA, caused by higher energy consumption or DE. MD was the most prevalent risk factor identified among the endurance athlete population, and oligomenorrhea/amenorrhea were seen among a large number of lean-sport athletes, with ranges from 35.5% to 60.7% (Barrack et al., 2014; Ackerman et al., 2015; Melin et al., 2015; Duckham et al., 2015; Tenforde et al., 2017; Clark et al., 2018; Brook et al, 2019; Tosi et al., 2019), where the presence of secondary amenorrhea was found in 18% to 27%, and oligomenorrhea, 30% to 64.0% (Hoch et al., 2011; Ackerman et al., 2015; Brook et al, 2019; Tosi et al., 2019), with a very high level of cases having irregular menorrhea, 72.3% (Yang et al., 2010; Duckham et al., 2015; Melin et al., 2015; Tenforde et al., 2015; Clark et al., 2018).

EA is shown to appear as a problem when having difficulties in eating enough during periods of high-intensity training or food restriction in order to obtain low body weight (Nattiv et al., 2007). Uncontrolled EA as a second component of the Triad in healthy young female adults, when EA drops under 30 kcal/kg FFM/day, has shown that within five days it can reduce blood glucose levels and hypothalamic-pituitary-axis hormones, and the luteal hormone (LH), which elevates cortisol (Loucks & Thuma, 2003). On the other hand, athletes with MD have shown an unfavorable lipid profile caused by low production of estrogen which effects lipid metabolism by decreasing LDL cholesterol and increasing HDL cholesterol (Schnaper, McGuire, Runyan, & Hubchak, 2000; Rickenlund, Eriksson, Schenck-Gustafsson, & Hirschberg, 2005). In the research of Melin et al. (2015) 25% of athletes had hypercholesterolemia, but with normal LDL/HDL ratio, and 38% of athletes had total cholesterol (TC) ≥5mmol/L. Some authors also found this relationship between high TC and patients with anorexia nervosa (Meczekalski, Podfigurna-Stopa, & Katulski, 2013), and a decrease of TC after weight gain (Ohwada, Hotta, Oikawa, & Takano, 2006). In the study of Melin et al. (2015) participants with increased TC had current low or reduced EA and/or DE (73%), while 33% were still eumenorrheic, suggesting that alterations and cholesterol synthesis might be triggered by low EA, despite normal weight and eumenorrhea. In the research of Clark et al. (2018) menstrual status was not associated with dyslipidemia. Dancers with amenorrhea and oligomenorrhoea consumed less energy than the eumenorrheic dancers (Yang et al., 2010), also low EA has been suggested to exist more commonly among athletes in endurance sports because of the metabolic demands of the sport (Melin et al., 2015; Clark et al., 2018) where this number of low/negative EA is even higher, 77%, found in professional dancers (Hoch et al., 2011), while in elite endurance athletes were 63% (Melin et al., 2015). Clinical EDs were conducted in leanness (46.7%) and non-leanness (19.8%) sports with a significantly high prevalence in leanness sports ($p<.001$) (Movaseghi et al., 2012).

In connection with the above mention, as the third group of components of the Triad, previous research showed a fast loss of bone in women with low plasma estrogen due to a decrease in bone formation and an increase in bone reapportion. Low plasma estrogen levels during the period of bone deposition may damage the peak of bone mass after a certain age. These athletes may not reach the expected peak of bone mass and may precociously develop osteoporosis, even after the resumption of menstrual cycles (Warren & Stiehl, 1999), which increases the risk of SF. Previous research confirmed this theory that a higher percentage of lean body mass positive correlates with higher BMD of the spine and total body among elite swimmers ($p<.05$) (Schtscherbyna et al., 2009) and that is not related only with athletes but also with sedentary individuals, where Hoch et al. (2009) were reported that low BMD was even at a higher percentage among sedentary women with 16% of athletes vs. 30% of their controls having low BMD. The authors explain this by the theory that exercise for strengthening muscles increases bone density that is common for non-leanness sports (Dadgostar, Razi, Aleyasin, Alenabi, & Dahaghin, 2009). In the research included in this study, Yang et al. (2010) explained that BMD among female dancers was relatively high, probably caused by high levels of weight-bearing physical activity. Whether they involving athletes or sedentary individuals, a positive correlation between MD and low BMD was indicated in previous (Øyen, Torstveit, & Sundgot-Borgen, 2009) and in current studies (Rauh et al., 2014; Melin et al., 2015; Nieves et al., 2016) and EA and low BMD (Nieves et al., 2016; Thralls et al., 2016). But, in their research Øyen et al. (2009) reported that women with < 5th percentile BMI were nine times more likely to report MD and have low BMD, and SF significantly correlated with athletes ($p<.001$). On the other hand, Rauh et al. (2010) reported that BMD does not necessarily correlate with SF, whereas in the same research authors also report that injured runners had low BMD of the spine ($p=.009$), total hip ($p=.03$), and whole-body ($p=.04$) compared to non-injured runners. Cases of SFs include as many as 47% of those focusing on running and weight bearing activities (Ackerman et al., 2015).

Since the first announcement of the American College of Sport Medicine in 1992 about a possible existence of the Triad (Nattiv et al., 1993; Yeager et al., 1993) until today, the awareness of the existence of the problem has stagnated (Brown et al., 2014). Brown et al. (Ibid.) studied the knowledge of the Triad by using current ACSM guidelines. The result showed that knowledge and awareness among athletes were very low (score: 2.79±1.61 out of 8) and among coaches were low, which gradually leads to the possibility that this problem may reach even more cases experiencing all of the components of the Triad. This low level of knowledge is confirmed in recent research published in 2019, with only 7% of the participants having heard of the components of the Triad (Tosi et al., 2019). This points to the lack of a solution to the problem during all these years which confirms the results of reviewed research in this study, where cross-country runners had the greatest proportion of bone stress injuries compared to other athletes (Joy et al. 2014; Tenforde et al., 2017) and endurance runners in 64.3% of the cases, then track and field runners in 32.1% and dancers in 3.6% of the cases (Barrack et al., 2014) which is far more than previously reported, 17% in marathoners (Torstveit et al., 2008).

CONCLUSION

Every exercise that leads an individual out of their comfort zone and professional monitoring bring risks of exhibiting some of the components of the Triad or all of them among the female population. In leanless sports there are more cases of experiencing these components than in non-leanless sports. Due to this, it is necessary to increase monitoring physically active women and in case of the appearance of some of the risks, act on the suppression of the lancet trace which leads to identifying all of the components of the Triad and experienced secondary indicators such as stress fractures and osteoporosis.

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DA LI ŽENSKA TRIJADA ZAISTA POSTOJI?

Trijada sportista (Trijada) je zdravstveno stanje sportista i odlikuju je tri komponente: nizak nivo energije (EA), menstrualna disfunkcija (MD) i niska koštano mineralna gustina (BMD). Prevalenca sve tri komponente Trijade kreće se od 1-14%. U poslednjih deset godina prevalenca se kretala u rasponu od 1.3% do 23% i kod 78% sportistkinja je utvrđena bar jedna od tri komponente Trijade. Cilj ovog sistematskog preglednog istraživanja je prikupljanje i analiza nedavnih studija o sportiskinjama sa Trijadom. Na osnovu analize elektronskih baza podataka i postavljenih kriterijuma za uključivanje, analizirano je 20 studija. Na osnovu analize izvedeni su sledeći zaključci: MD je bio najrasprostranjenija među sportistkinjama izdržljivosti u rasponu od 35.5% do 60.7%, uz prisustvo sekundarne amenoreje i oligomenoreje, 30% do 64.0% i 18% do 27.0% i vrlo visoke učestalosti neredovne menoreje (72.3%). Nizak/negativan EA se kreće od 19.8% za sportiste sa nižim nivoom bezmasne komponente do 77%. Sportovi u kojima je izražena mršavost, uključujući trčanje, gimnastiku i lakros, imaju najveći udeo sportistkinja u kategorijama umerenog i visokog rizika ka Trijadi. Preporuka za buduća istraživanja je da treba da budu fokusirana na pojačan nadzor fizički aktivnih žena, kako bi se u slučaju pojave nekih od rizika, delovalo na prevenciji Trijade, preloma i osteoporoze.

Ključne reči: *trijada sportista, stres fraktura, nivo energije, menstrualni poremećaji, amenoreja, koštano mineralna gustina*

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Research article

MOTOR SKILLS OF SOCCER PLAYERS AGED 16-18 IN REGARD TO COMPETITION LEVEL AND PLAYING POSITION

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Abstract. *The aim of this paper was to examine the differences in the motor skills of soccer players aged 16-18 years who play in different competition levels (National League and Regional League), as well as players who play in different positions in the team. The standard testing battery for the motor skills assessment of soccer players was used to evaluate the motor skills. As for the evaluation of the differences between the different playing positions, a two-factor ANOVA with the factor Competition Level (National and Regional Level) and the factor Position (forward, midfielder, side defender, central defender) was used. A two-factor ANOVA with the factor Competition Level (National and Regional Level) and the factor Age (16, 17 and 18 years of age) was used to evaluate the differences between the different quality levels. The study included 126 male soccer players 16 to 18 years of age (N_{16}=45, N_{17}=41, N_{18}=40) divided into 4 positions on the team: forwards (N=37, BH=179.2±5.0, BM=70.1±6.6), midfielders (N=48, BH=177.9±6.3, BM=69.6±7.9), side defenders (N=22, BH=176.6±5.4, BM=67.5±5.7) and central defenders (N=19, BH=184.0±4.3, BM=72.3±6.6). Because of significantly different activities in the field, the goalkeeper position was excluded from this study. The results indicate that motor skills do not differentiate players of different competition levels, and that there is a gap between players aged 18 years in aerobic endurance which is the basis of success in soccer. Also, the obtained results suggest that motor skills could differentiate players at certain positions. However, it was specifically found that only alactic capabilities type of speed and agility, differentiate forwards from other positions, especially from midfielders.*

Key words: *Soccer, Motor Skills, Team Position, Competition Level, Youth Players.*

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INTRODUCTION

The game of soccer has been constantly evolving since its origins both in terms of the game as a whole, and of the transformation of individuals as an integral and indivisible part of soccer game. The present level of soccer development characterized by great dynamics and high rhythm of the game requires exceptional physical preparedness, high levels of movement technique (Sever & Zorba, 2017), tactical awareness and mental stability.

During a soccer game, players perform a variety of activities and movements with the ball and without it. In doing so, players unintentionally (and unexpectedly) change the intervals of high and low intensity, as well as their duration. Therefore, the game of soccer can be described as a complex activity with acyclic intervals. During a match, a player performs between 1400 and 1600 changes of intensity and direction of movement, or changes every 3.5-4 seconds (Verheijen, 1998). On the other hand, players sprint every 90 seconds, on average, and have high-intensity efforts every 30 seconds (Reilly, Bangsbo, & Franks, 2000). Players with a high level of motor and functional abilities can exert adequate technical-tactical skills throughout the duration of a match.

Otherwise, it is well-known that one soccer team consists of 11 players in the field (including the goalkeeper) and who are, based on their activities, position in the field and the tasks arising from these positions, classified as defenders, midfielders and forwards (Commeti, Maffiuletti, Pousson, Chatard, & Maffulli, 2001; Vaeyens et al., 2006). Such a classification and division of players within a team results in different requirements in technical, tactical, morphological, functional, motor, psychological manifestations of each individual based on their position on the team (Di Salvo et al., 2007).

Although modern players should be able to play in different positions, the truth is that every position on the team is associated with a number of specific tasks.

With regard to the competition level, the distance covered in high intensity is an important criterion for the division of top players and those with lower skills (Jovanović, Sporiš, Omrcen, & Fiorentini, 2011). Mohr, Krustrup, P., & Bangsbo (2003) found that high-level players cover 28-58% longer distances of running at high intensity (>19km/h) and sprint, compared to players playing at lower levels [high intensity running 2.43±0.14 km vs. 1.90±0.12 km: sprint 0.65±0.06 km vs. 0.41±0.03 km (Mean±SD). Accordingly, there was a significant difference in the endurance of the soccer players at various competition levels measured by different tests, both among the senior, as well as in junior players (Krustrup et al, 2006; Rostgaard, Iaia, Simonsen, & Bangsbo, 2008; Rebelo et al., 2013).

Motor skills have a greater discriminatory power than anthropometric characteristics and therefore can be taken as a primary element of identification and selection of young players. It is widely known that players at the highest competition level have the highest level of motor skills in general. Therefore, the results successively decrease as we reach lower competition levels. Differences are mainly manifested in those variables that are more strongly influenced by the training procedure (Joksimović et al., 2008).

Previous studies have shown that professional players in European leagues performed sprints within 5 s in 90% of cases (Andrzejewski, Chmura, Pluta, Strzelczyk, & Kasprzak, 2012). Therefore, the ability to accelerate within a maximum of 5 seconds stands out as an important factor of success in soccer. Thus, elite players had significantly higher speed levels on the 10m sprint compared to lower competition level players (Pssota, Bunc, Netscher, Mahrová, & Nováková, 2006; Haugen, Tønnessen, & Seiler, 2012).

When it comes to game requests, a high level of explosive power is an advantage in the individual tackles in the air and, consequently, in the running economy. That conclusion has been made due to a significant correlation between the sprint at 10 to 30 m and vertical jumps in elite players (Wisløff, Castanga, Helgerud, Jones, & Hoff, 2004). Significantly higher values of lactate tolerance, isokinetic knee extensor strength and vertical jump ability were found in players whose teams achieved better results at the national level (Kalapotharakos et al., 2006). These results were also confirmed at the international level, where significant differences were observed in the explosive abilities measured by different vertical jumps between European and African players on the one hand, and Asian players, on the other (Wong & Wong, 2009), but also between Spanish and Icelandic players (Arnason et al., 2004; Casajüs, 2001).

Some players may be more genetically adaptable to training stimuli, particularly with respect to the relative distribution of muscle fibers. Therefore, physiological responses to exercise can be highly dependent on dominant muscle fiber type (Reilly et al., 2000).

Professional soccer today is played at a higher pace than 20-30 years ago. Therefore, it is likely that the physiological factors of high rates of energy production during the match gained significance in the context of raising functional abilities of soccer players. For example, values of aerobic power, such as maximum oxygen uptake (VO2max) can have a greater influence on successful performance. Consequently, having a relatively high threshold of oxygen utilization can be an important criterion in the assessment of youngsters. However, it is doubtful how present the level indicators of high fitness are from childhood to adulthood (Reilly, Williams, Nevill, & Franks, 2000).

Soccer is a team sport, and therefore a win against an opponent, as the ultimate goal in a soccer match, depends both on the quality of each individual player, and on compatibility between them (Gil, Ruiz, Irazusta, Gil, & Irazusta, 2007). Therefore, for greater efficiency, the players are placed in different positions in order to meet specific tasks and provide team superiority (Stølen, Chamari, Castagna, & Wisløff, 2005; Wong & Wong, 2009). During the game, players at different positions have different requirements. Therefore, midfielders cover the greatest distance (between 10 and 13 km), compared to the other players, while goalkeepers run around 4km in 90 minutes (Wisløff, Helgerud, & Hoff, 1998). Given the fact that there are different requirements in the match, differences were found in elite players based on their physical characteristics in different positions they play.

Most of the research has shown that explosive activities, like speed and agility do not differentiate players by playing position (Dauty, Bryand, & Potiron-Josse, 2002; Strudwick, Reilly, & Doran, 2002; Rampinini et al., 2007; Wisløff et al., 2004; Taskinen, 2008). There are several studies that have shown better results of forwards compared to other positions with regard to the sprint up to 20 m (Sporiš, Jukić, Ostojić, & Milanović, 2009; Pivovarniček, Pupiš, Tonhauserová, & Tokárová, 2013). On the other hand, in jumping activities, measured by squat jumps and countermovement jumps with an arm swing, significantly better results were observed in goalkeepers and central defenders (Lago-Penas, Lago-Ballesteros, & Rey, 2011; Boone, Vaeyens, Steyaert, Vanden Bossche, & Bourgois, 2012), while midfielders showed significantly lower scores than other positions on the team (Haugen et al., 2013).

The aim of this paper was to examine differences in motor skills of soccer players aged 16-18 years who play in different competition levels (National League and Regional League), as well as players who play in different positions on the team.

METHODS

The study included 126 soccer players, aged 16 to 18 years (16 years N=45, 17 years N=41, 18 years N=40), divided into 4 positions: forwards (N=37, BH=179.2±5.0 cm, BM=70.1±6.6 kg, Mean±SD), midfielders (N=48, BH=177.9±6.3 cm, BM=69.6±7.9 kg, Mean±SD), side defenders (N=22, BH=176.6±5.4 cm, BM=67.5±5.7 kg, Mean±SD) and central defenders (N=19, BH=184.0±4.3 cm, BM=72.3±6.6 kg, Mean±SD). As the goalkeeper's activities are fundamentally different from other players, the goalkeeper's position was excluded from the study. All of the participants actively exercise in their teams. They are members of competitive selections, each in their own age group.

This research was conducted on the basis of standard testing of motor skills in young soccer players, members of the club whose selections compete in the highest ranking of competitions in Serbia (U19 and U17 League of Serbia; N=52) and the club whose selections compete in the second highest ranking competitions in Serbia (Belgrade U19 and U17 League; N=74). The testing was done in two days, seven days before the start of the championship, after all the tested teams had passed the entire preparatory period with the team. Each test was performed on an outdoor soccer pitch with artificial turf, jumping tests on a hard surface, while anthropometric tests and the Sit & Reach test were done at the club premises. Every participant wore the appropriate sports equipment.

A standard battery of tests was used to assess the motor skills of soccer players, which provide a total of 12 dependent variables to assess speed, agility, leg muscle power, speed endurance, endurance and flexibility.

The acceleration, i.e., the player speed, is estimated by a test in which the task is to run at maximum speed for 30 meters. During the testing, three variables were obtained: time in Sprint at 10m - S10M (in s); time in Sprint at 20m with flying start - S20MF (in s); time in Sprint at 30m - S30M (in s). The start of the measurement is defined by the intersection of the infrared ray of the first photocell, while the end is defined by the intersection of the infrared ray of the last, third photocell.

The agility, i.e., the acceleration, deceleration, rapid change of direction of movement, is estimated on the basis of the time for running a total distance of 20 meters, in the so-called zigzag trajectory. According to the testing protocols, the participants performed this test: without a ball - ZIGZAG (in s); and with a ball - ZIGZAGBALL (in s). The beginning of the measurement is defined by the intersection of the infrared ray of the first photocell, while the end is defined by the intersection of the infrared ray of the second photocell.

The leg muscle power, i.e., the assessment of the ability to perform maximum jumps, was performed by a test where the task was to achieve the maximum vertical height of the jump, by: leaping from the semi-squat - SJ (in cm), which assesses the explosive power of the lower extremities, especially knee extensors muscles; then jumps which contain elements of countermovement - CMJ (in cm); and arm swing - CMJA (in cm), which were used to estimate the relative contribution of elastic potential, and the post-active transfer (arm swing). An infrared sensory mat was used for these tests to measure the jump height based on the duration of the flight phase.

The speed endurance was assessed using the 6 repetitive sprints at 30 meters, with a 10 second recovery time between sprints (modified RAST test). The assessment was made on the basis of: the average time of 6 sprints - RASTAVG (in s); as well as the ratio of fastest and slowest attempts - RAST% (in %). The beginning and end of the test, as in the speed and agility tests, are defined by the intersection of the infrared ray of the photocells.

The aerobic endurance was evaluated on the basis of the total distance covered in the YoYo Intermittent Recovery Test - Level 1 - YOYO_ IR_1 (in m). This test was performed by running 20m back and forth, with pace dictated by an audio signal followed by a 10-second pause to walk 5m back and forth. The pace of running increased progressively according to the test protocol, to the point where the participant was unable to follow the pace dictated by the audio signal.

The Sit & Reach test - S&R (in cm) was used to assess the flexibility of the hip extensors and lower back muscles, using a standard bench.

Research data were analyzed using the descriptive and comparative statistical procedures, and using the statistical software SPSS 20.0. A two-factor analysis of variance with factors Competition level (National and Regional level) and Team Position (forwards, midfielders, side defenders and central defenders) was used to evaluate the differences between the individual positions in the team. A two-factor analysis of variance with factors Competition level (National and Regional Level) and Age (16, 17 and 18 years) was used to evaluate differences between different qualitative levels.

RESULTS

Figures 1-4 show the results of the variables examined for different positions in the team, with the corresponding differences between them.

Figure 1 shows the results of the tests for assessing speed abilities sorted by position on the team, regardless of age and competition level. The results indicate statistically significant differences between forwards and midfielders in all the three observed variables: sprint at 10m (p=0.031), sprint at 20m with flying start (p=0.0001) and sprint at 30m (p=0.0001).

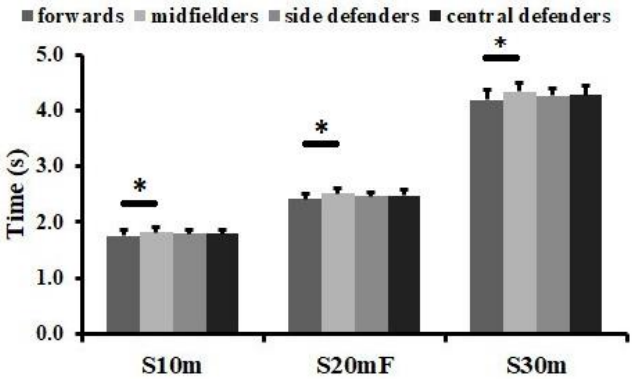

Fig. 1 Differences between playing positions in speed tests

Figure 2 shows the results of the tests for assessing agility, sorted by team position, regardless of age and competition level. As in the previous image, statistically significant differences between forwards and midfielders can be observed in the agility test without a ball (p=0.009), while there are no differences between the observed groups in the agility test with a ball.

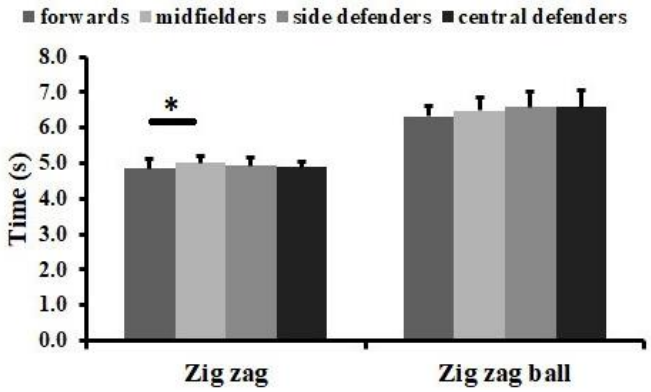

Fig. 2 Differences between playing positions in agility tests

Figure 3 shows the results of tests for the assessment of the leg muscle power based on different jump protocols sorted by team position, regardless of age and competition level. Unlike the previous cases, none of the observed variables showed a statistically significant difference between individual positions on the team.

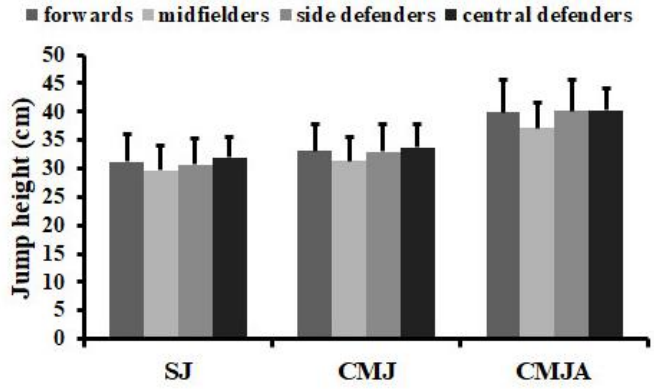

Fig. 3 Differences between playing positions in leg muscle power assessment tests

Figure 4 shows the results of the tests for the assessment of speed endurance and aerobic endurance ranked by team position, regardless of age and competition level. No test showed a statistically significant difference between the groups, except that in the speed endurance test assessed through the ratio of the best and worst attempt, the result was borderline significant in favor of midfielders against forwards ($p = 0.056$).

Regarding the test for flexibility, no significant differences were observed between the groups tested by team position (forwards: 12.6±6.7 cm, Mean±SD; midfielders: 14.3±5.0 cm, Mean±SD; side defenders: 14.4±6.1 cm, Mean±SD; central defenders: 13.7±5.2 cm, Mean±SD).

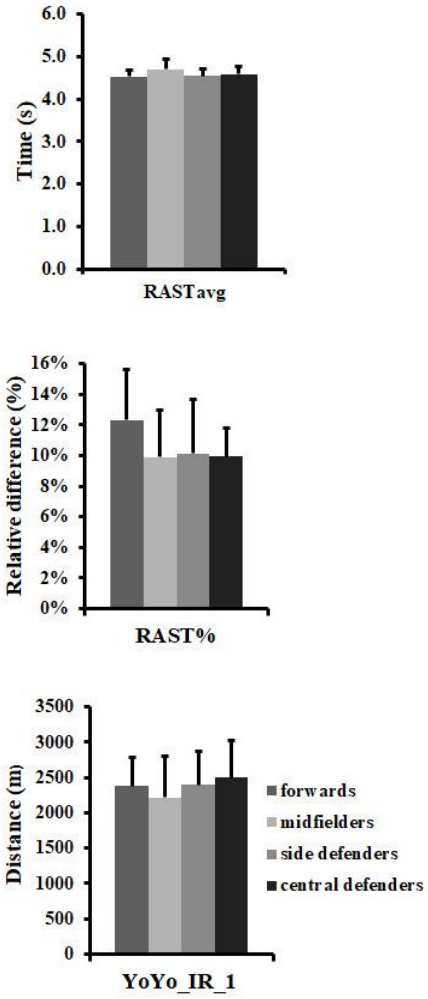

Fig. 4 Differences between playing positions in endurance assessment tests

Table 1 shows the results of a two-factor ANOVA with the factors of Competition Level and Team Position. According to the data in this table, it is observed that there is a statistically significant difference in the agility test with a ball (ZIGZAGBALL) between forwards of different levels ($p = 0.031$), with better results achieved by forwards at the National level (6.021±0.691 s vs. 6.528±0.388 s, Mean±SD).

On the tests for assessing leg muscle power, forwards and midfielders of the Regional level scored statistically better than National level players [SJ: 32.5±4.8 cm vs. 29.3±4.1cm for forwards, or 30.8±4.7 cm vs. 28.3±3.4 cm for midfielders; CMJ: 34.7±4.8cm vs. 30.7±4.0 cm for forwards and 32.9±4.2cm vs. 29.4±3.4 cm for midfielders; CMJA: 41.7 ± 5.2cm vs. 37.3±5.3cm for forwards and 38.5±7.9 cm vs. 35.3±3.6 cm (Mean±SD) for midfielders].

There are also statistically significant differences in the assessment of speed endurance over the ratio of the best and worst results. As for the results for power assessment, when assessing speed endurance, forwards and midfielders at the Regional Level achieved better results, namely, there is a relatively smaller difference between the best and worst sprints [11.2±2.9% vs. 14.0±3.1% for forwards and 9.1±2.5% vs. 11.6±3.6% for midfielders (Mean±SD)]. This test was performed exclusively by U19 selections, that is, players aged 17 and 18. The reason lies in the fact that buffer systems start to develop at the age of 17, so it is considered that there was no need to test younger players. It should be noted that a modified RAST test was performed, since the original RAST test was performed for 6 * 35 meters; in this study 6 * 30 meters were performed, as the sprint test was performed at the same distance. Finally, National team players scored significantly better on the endurance assessment test (YoYo_Ito_1), especially midfielders [2421±631 m vs. 2038±488 m), and central defenders (2926±450 m vs. 2250±410 m, Mean±SD)].

Table 1 Two-factor ANOVA for all variables (factors: Competition level and Team position)

ANOVA (level*position)	Forwards	Midfielders	Side defenders	Central defenders
S10M F=0.061, p=0.980	0.573	0.494	0.972	0.574
S20MF F=0.292, p=0.831	0.454	0.122	0.749	0.165
S30M F=0.025, p=0.995	0.858	0.633	0.853	0.670
ZIGZAG F=0.753, p=0.523	0.403	0.089	0.350	0.496
ZIGZAGBALL F=0.723, p=0.540	0.031*	0.205	0.265	0.812
SJ F=0.513, p=0.674	0.031*	0.048*	0.468	0.876
CMJ F=0.719, p=0.543	0.006*	0.005*	0.338	0.640
CMJA F=0.444, p=0.722	0.006*	0.020*	0.305	0.448
RASTAVG F=0.209, p=0.890	0.623	0.715	0.235	0.655
RAST% F=0.465, p=0.708	0.020*	0.045*	0.522	0.334
YOYO_IR_1 F=1.315, p=0.273	0.300	0.008*	0.448	0.004*
S&R F=0.016, p=0.997	0.415	0.232	0.390	0.539

* p<0.05 (statistically significant difference according the competition level)

Figures 5-8 show the results of a two-factor analysis of variance (ANOVA) with the influence of factors Competition level and Age.

Figure 5 shows the results for assessing the ability to perform in the alactic mode, more specifically in sprinting and agility without a ball and with a ball. The difference

between the two levels of competition is only at the age of 16 in sprinting at 20m with a flying start in favor of National level players. On the other hand, in the domain of agility, a difference was observed only in agility with a ball at the age of 17, also in favor of National level players (p=0.001).

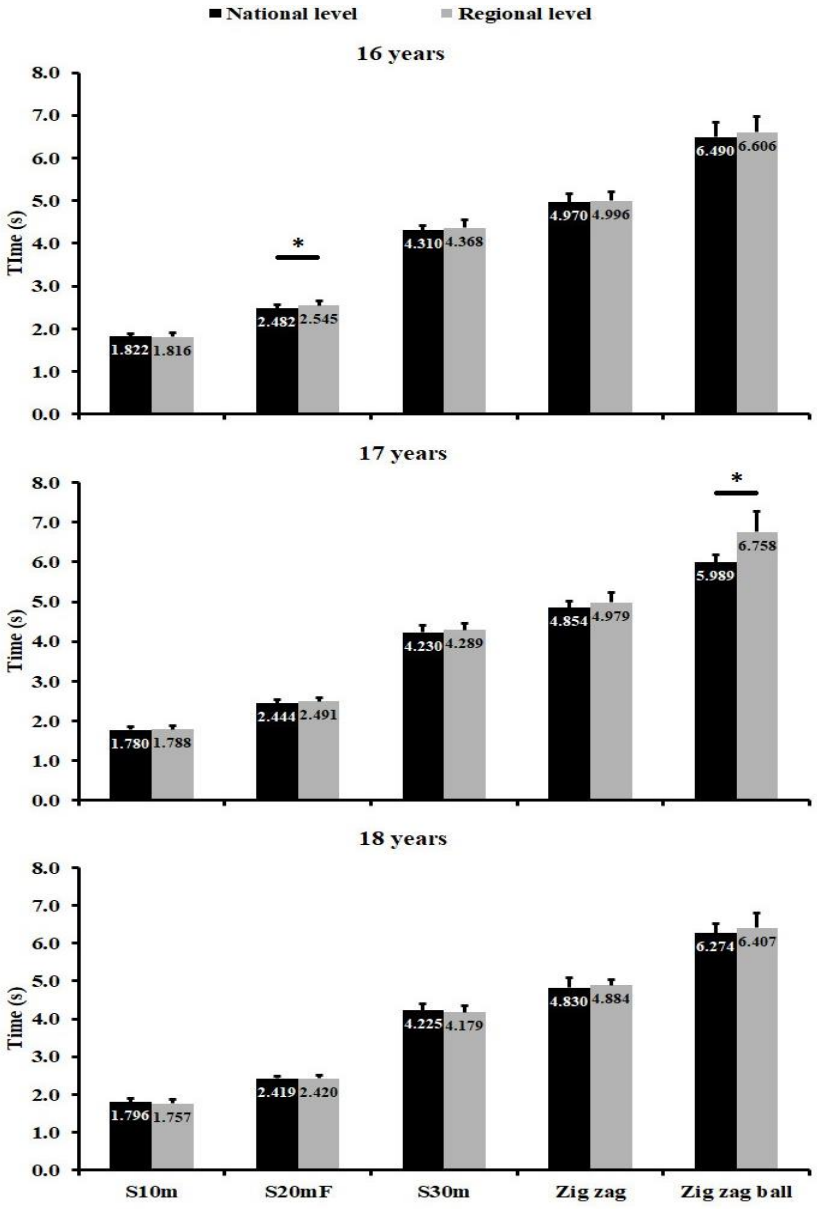

Fig. 5 Differences between competition levels in speed and agility assessment tests for each age group

Figure 6 shows the results of the tests for the assessment of leg muscle power depending on age and competition level. Significant differences were observed with respect to the competitions level in countermovement tests at age 16, but also in all jump modalities at age 18 ($p<0.05$), all in favor of Regional level players.

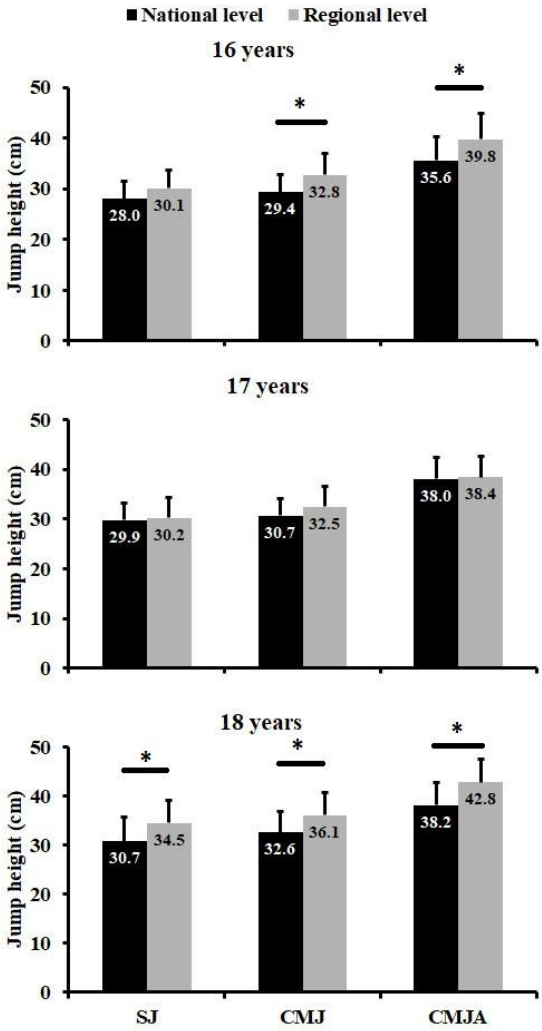

Fig. 6 Differences between competition levels in leg muscle power assessment tests for each age group

Figure 7 shows the results of the tests for two types of endurance: speed endurance and aerobic endurance. The results indicate statistically significant differences in the assessment of speed endurance assessed by the ratio of the best and worst attempts at the age of 17 in favor of players of the Regional competition level [9.6±2.7% vs. 12.8±2.9%. cm (Mean±SD); p=0.001]. On the other hand, significant differences were observed in the endurance test at age 18, but in favor of National level players [2817±601 m vs. 2297±413 m (Mean±SD), p=0.002].

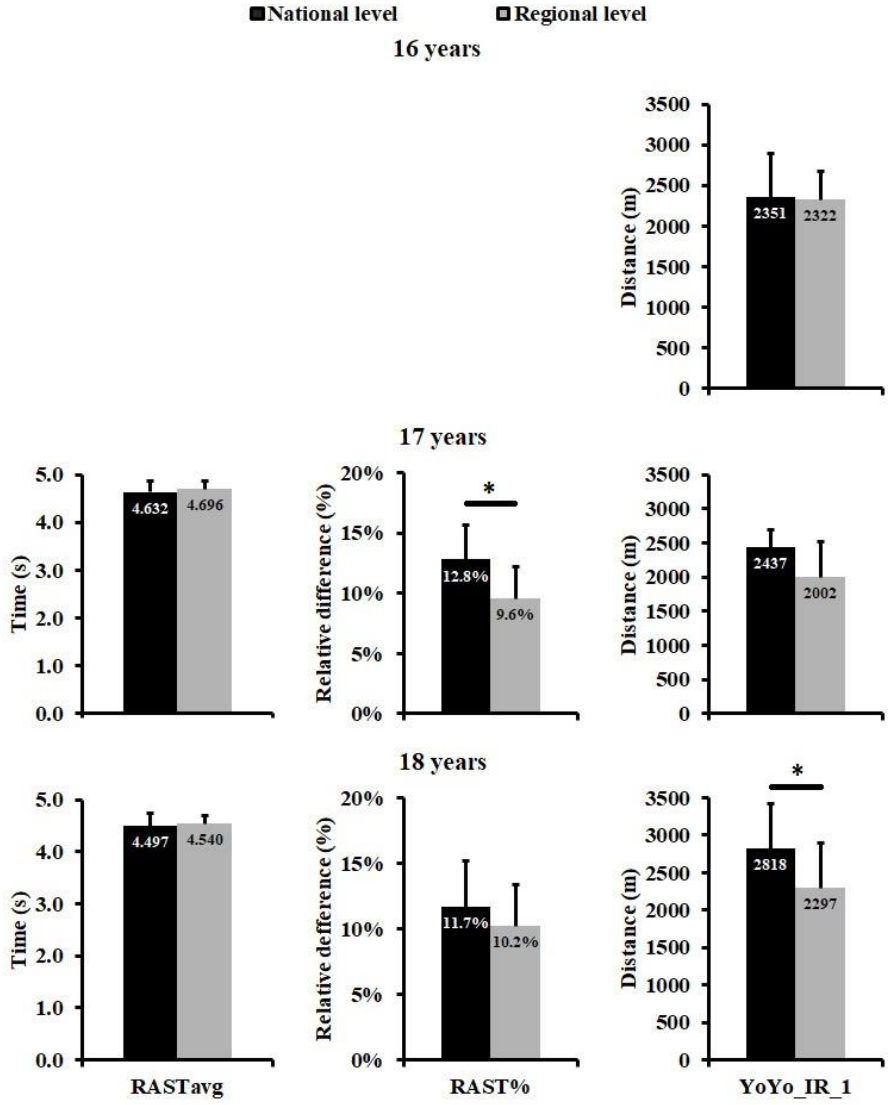

Fig. 7 Differences between competition levels in endurance assessment tests for each age group

DISCUSSION

Prior to the discussion, it should be emphasized that the results obtained from this study could help coaches in the individualization of training programs, as well as in the further programming of the training process. Accordingly, the overall aim of this study was to determine the differences between the two levels of competition, as well as differences in team positions, based on the results obtained by a battery used to test motor skills.

In addition, some methodological aspects relevant to drawing adequate conclusions must be emphasized. First of all, it must be emphasized that positions in soccer cannot be so easily determined. Given that the common occurrence of "false nines", "half-attackers", as well as "midfield line corrector", it is difficult to determine which positions are standard. For the purpose of this paper, it was decided to define four positions, except that there was a fifth position (goalkeeper), but due to the small sample size, as well as the generally different movement structure, this position was excluded from the statistical analysis. There is also the winger position, as well as central and side midfielders that should be considered. In particular, it should be noted that this study would certainly have been more complete if another competition level was examined.

The results obtained in this study regarding the competition level show that, at least in this case, there are no significant differences in most of the variables tested, as was expected. The National level players showed the biggest difference in speed and endurance tests. Again, when looking at modern soccer, those two abilities are in fact among the most important ones for a successful game. On the other hand, the Regional level players showed the highest quality in explosive power assessment tests. Given that these were two different clubs, or two different soccer academies tested, it is possible that the results are the result of a different approach to training, that is, different selections.

Regarding the results obtained by comparing different team positions, it can be concluded that in the activities up to 5-6 seconds, or in alactic mode, the forwards are ahead of others, which is in accordance with the profile of the position they are performing, but also in line with a number of previous studies (Dauty et al., 2002; Sporiš et al., 2009; Deprez et al., 2014). Specifically, a study conducted by Gil et al. (2007) highlighted the forwards as players with the highest level of motor skills, especially when looking at youth players [age 17.31±2.64 years (Mean±SD)] who do not play at the top level (Gil et al., 2007). Similar studies have shown that in the Norwegian league both forwards and central defenders have a higher level of alactic abilities than midfielders, indicating the importance of these abilities in young players' selection and development (Wislöff et al., 1998).

On the agility test without a ball (ZIGZAG) there is a statistically significant difference between the forwards and the midfielders. Such a result is linked to speed tests, given that agility, as an ability, is more pronounced in forwards, unlike midfielders. It is interesting to note from Figure 2 that forwards performed better than other players on the test with a ball as well. This is surprising given the fact that forwards did not use to have as good ball control at full speed with a change of direction, as midfielders for example. This information also tells us that soccer primarily focuses on the forward position. While it used to be just a classic striker, a classic "nine", with dominant motor skills, especially in jumping, as well as with a refined sense of goal and the ability to strike from any position, things are different now. Nowadays, midfielders, or midfielders behind the forwards, are closer to the goal and, in different playing systems, forwards may be wingers, or "false nines". Therefore, the occurrence of forwards with excellent technique, ball control, ball reception, ball striking is

becoming more and more common, and there are many examples in today's soccer where we have athletic forwards with the technique of the best midfielders.

Assessment tests for explosive power of the lower extremities and the relative contribution of elastic potential (SJ, CMJ, and CMJA) showed no difference between team positions, which is in line with previous studies (Pivovarniček et al., 2013).

It is interesting to note that in this study, side defenders did not exhibit any specific ability compared to other positions on the team. On the RAST test, side defenders were expected to have the best result, but that did not happen. Given that in this position, the player should have the most pronounced ability for back and forth running, it is simply unclear how at any level and at any age they did not produce the expected results. A possible reason is that it appears that there are fewer good side defenders in present soccer, and that the players of such predispositions are getting closer to the goal, in the position of the side forwards or wingers.

Regarding the Competition level factor, the assumption was made that the players of the National level have better performance on the endurance test than their peers from the Regional level. We can find the answer in the fact that maximum oxygen consumption (VO2max) is one of the basic predictors of top soccer, and therefore, if two levels are involved, it is logical that a higher level has greater demands in play and movement. As for speed endurance, the results depend solely on the coach's training methods, with the RAST test as a measure of player fitness. The results are expected to improve with age and competition level (Abrantes, Maçãs, & Sampaio, 2004), and reasons for unexpected results (regional level players better than national level players) should be sought in the fact that buffering systems responsible for this ability start to develop at the age of 17, so this ability still does not differentiate players of this age.

CONCLUSIONS

This research aimed to prove the assumptions that motor skills differentiate players based on their competition level and position on the team. In addition, it aimed to prove that forwards and central defenders are the best in alactic activities, as well as that midfielders are the best in aerobic activities, and that side defenders are the best in lactic activities. The results of this research indicate that motor skills do not differentiate players by competition level, which is explained with the way their training sessions are prepared. Since the testing was conducted after the teams had passed the preparatory period, there is a possibility that the coaches may have had different goals during the preparation. Since the gap exists in the U19 selection in aerobic endurance that underlies soccer performance, it can nevertheless be argued that this hypothesis is partially confirmed.

In terms of team positions, it can definitely be argued that motor skills differentiate players in particular positions. However, individually, the alactic abilities of the speed and agility type have been shown to differentiate forwards from other positions, especially from midfielders. Therefore, it can be argued that the hypothesis that forwards and central defenders are better than other positions in alactic activity is only partially confirmed.

Apart from these results, there is a slight ambiguity about the position of the side defenders, since the expected results have not been achieved. This means that in some future studies, particular attention must be paid to this position, given that side defenders can play both defense and attack.

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FUNKCIONALNE SPOSOBNOSTI FUDBALERA PREDPUBERTETSKOG UZRASTA U FUNKCIJI RANGA TAKMIČENJA I POZICIJE U TIMU

Cilj rada je da se ispitaju razlike u motoričkim sposobnostima fudbalera uzrasta 16 – 18 godina koji igraju u različitim nivoima takmičenja (Lige Srbije i Lige Beograda), kao i fudbalera koji igraju na različitim pozicijama u fudbalskom timu. Za procenu motoričkih sposobnosti korišćena je standardna baterija testova za procenu motoričkih sposobnosti fudbalera. Za procenu razlika između pojedinih pozicija u timu korišćena je dvofaktorska analiza varijanse sa faktorima rang takmičenja (Savezni i Regionalni rang) i pozicije u timu (napadač, vezni, spoljni i odbrambeni). Za procenu razlika između različitih kvalitativnih nivoa primenjena je dvofaktorska analiza varijanse sa faktorima rang takmičenja (Savezni i Regionalni rang) i uzrast (16, 17 i 18 godina). Istraživanjem je obuhvaćeno 126 momaka, uzrasta od 16 do 18 godina (N_{16}=45, N_{17}=41, N_{18}=40), podeljenih na 4 pozicije: napadač (N=37, VT=179.2±5.0, MT=70.1±6.6), vezni (N=48, VT=177.9±6.3, MT=69.6±7.9), spoljni (N=22, VT=176.6±5.4, MT=67.5±5.7) i odbrambeni igrači (N=19, VT=184.0±4.3, MT=72.3±6.6). Kako se aktivnosti golmana u osnovi značajno razlikuju od ostalih igrača, pozicija golmana je isključena. Rezultati istraživanja navode da motoričke sposobnosti ne diferenciraju igrače prema rangu takmičenja, kao i da postoji razika u uzrastu 18 godina u aerobnoj izdržljivosti koja je osnova uspešnosti u fudbalu. Dobijeni rezultati ukazuju da se može tvrditi da motoričke sposobnosti diferenciraju igrače na pojedinim pozicijama. Međutim, pojedinačno gledano jedino se pokazalo da alaktatne sposobnosti tipa brzine i agilnosti, diferenciraju napadače od ostalih pozicija, naročito od veznih igrača u fudbalskoj igri.

Ključne reči: *fudbal, motoričke sposobnosti, pozicije u fudbalskom timu, nivo takmičenja, mladi fudbaleri*

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Review article

THE EFFECTS OF PHYSICAL ACTIVITY ON OBESITY AMONG THE ELDERLY – A SYSTEMATIC REVIEW

UDC 615:796

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Abstract. *The aim of this review research was to determine the effects of the physical activity (PA) on obesity among the elderly. To compile existing studies on the effects of PA on obese elderly individuals, PubMed, SCIndeks, PEDro, J-GATE, DOAJ and Google Scholar electronic databases were searched. By analyzing and applying the set criteria, the final analysis included 20 studies, and the positive influence of the PA on the obesity of the elderly was confirmed. The greatest effect on the decrease in body mass was achieved by the simultaneous application of a combination of exercise programs and dietary regimen for a period of 6 months. It was concluded that combined programs of aerobics, weight training, flexibility and balance exercises for a period of at least 12 weeks lead to a mild decrease in body mass and the amount of fat mass, while maintaining and increasing lean body mass mostly in the form of muscle tissue. PA is an effective mean in reducing obesity, and thus its use among the elderly is recommended.*

Key words: *Physical Exercise, Ageing, Body Composition, Body Mass Index, Weight Loss.*

INTRODUCTION

Pronounced demographic changes and the increase in the number of the elderly with certain health issues characteristics for their age have been a feature of most countries in the world over the past two decades. Poor habits and lifestyle choices at a young age are described as possible triggers for the health disorders later in life, e.g. diabetes or cardiovascular diseases are the most common health disorders that are caused largely by unhealthy habits (Chan & Woo, 2010; Sourtzi et al., 2019). Obesity, as a consequence of insufficient physical activity (PA) and an inappropriate way of life represents one of the quickest growing trends among the elderly population. As a result, physical exercise (PE) is

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recommended as one of the most effective means of solving the aforementioned problem (Han, Tajar, & Lean, 2011; Petrović & Marinković, 2018), as it also contributes to the improvement in quality of life, increase in muscle strength, and endurance (Blair, LaMonte, & Nichaman, 2004). In addition to numerous recommendations regarding the frequency and intensity of the physical activities of the elderly, the effects of the applied exercises, due to great variations in the aging process, according to certain authors, primarily depend on the health status, psychophysical characteristics and functional abilities of each individual (Taylor et al., 2004).

During the normal aging process, changes in body composition occurs in the form of a decrease in muscle mass and increase in fat mass, that is, the development of sarcopenia, which represents an important cause of bone brittleness, instability, the occurrence of disability and loss of independent movement among the elderly (Weinheimer, Sands, & Campbell, 2010). In addition to the effects of PE on the elderly, related to the prevention and eradication of sarcopenia and cachexia through a combination of aerobic and weight training exercises (Scalabrin & Caporossi, 2016), it was determined that PA have a beneficial effect on relieving joint pain among individuals with rheumatoid arthritis, osteoarthritis, osteoarthritis of the knees, chronic obstructive pulmonary disease (Rejeski, Brawley, & Shumaker, 1996), a decrease in fatigue, increase in energy (Cochrane, Munro, Davey, & Nicholl, 1998) and quality of sleep (Singh, Clements, & Fiatarone, 1997). Obesity, accompanied by physical weakness and other health complications due to a decrease in daily PA, represents one of the main causes of the occurrence of disability among the elderly (Villareal, Banks, Siener, Sinacore, & Klein, 2004). This inactivity is related to low percentages of lean body mass (LBM) and increased amount of body fat (BF), a decrease in muscle mass and quality of life. As the number of the elderly in the world population is increasing, and obesity is proving to be one of the greatest problems of modern times, the question is: "What are the effects of the PA on obesity among the elderly, and what type of the PE has the greatest effect?"

The aim of this research is to determine the effects of PA on obesity among the elderly.

METHODS

The tasks that originated from the research aim included: 1) a search of electronic databases; 2) the compilation and translation of existing literature from English; 3) an analysis of the research results; and 4) result representation, that is, determining the effects of exercise programs on obesity among the elderly.

To compile existing studies on the effects of the PA on obesity among the elderly, the following electronic databases were searched: PubMed, SCIndeks, PEDro, J-GATE, DOAJ and Google Scholar. Following the compilation of the relevant data from studies previously carried out from 2000 to 2017, under the assumption that the PA has a positive effect on the reduction of obesity among the elderly, an evaluation of its effects was carried out.

During the database search, the following key words were used: exercise, ageing, body composition, body mass index, weight loss, health promotion. The titles of identified studies, their abstracts and entire texts were read and analyzed. The research was carried out by several authors, and the studies were analyzed in detail based on the set criteria.

Inclusion criteria

In order for a study to be included in the final analysis, it had to satisfy certain criteria:

- that it included obese individuals with a body mass index ≥30 (Body mass index – BMI=kg/m²);
- that it included obese elderly individuals, with an average age ranging from 55 to 80, independent of lifestyle;
- that the experimental group took part in an exercise program as part of which the evaluation of the effects of the PA on obese elderly individuals took place;
- that the study was written in English.

The experimental studies which met the set criteria were analyzed afterwards and presented based on the following parameters: references (the author's initials and date of publication of the study), the sample of participants (health status, age, overall number and subgroups of the participants), the PE program, the duration and frequency of the PE, the research results.

Exclusion criteria

The exclusion criteria included:

- that the study was carried out on a sample of participants whose average age is outside the range of 55 to 80;
- that the study was not published in English.

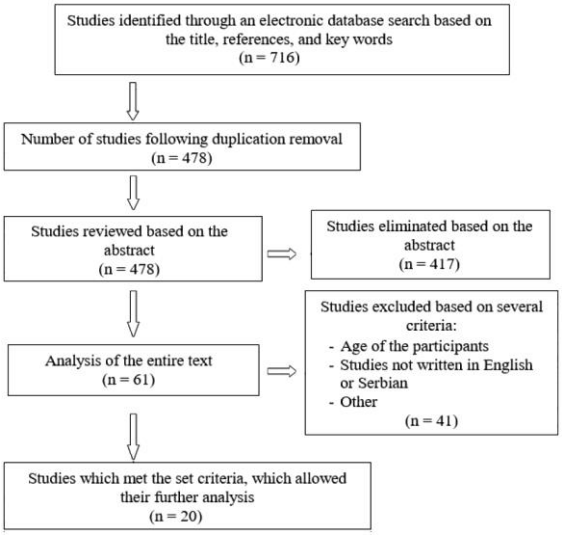

Fig. 1 The flow diagram

RESULTS

The search of the electronic databases identified 716 studies on the relevant topic. Following a further analysis and application of the set criteria, in accordance with the aims of this study, the final analysis included 20 studies, as can be seen from the following Flow diagram 1.

Table 1 A systematic review and the characteristics of the participants included in the studies

Study (year)	Health status	Gender	Age of the participants (Mean±SD)	Sample size (n)	BMI (kg/m²)	Number of participants per group	Duration Frequency (days/ weeks)	Intensity Duration of the training (min)	Type of the activity	Results (p)
Womack et al. (2000)	Obese individuals	M	60 ± 8	n = 81	EG_1 BMI = 30.4 ± 2.5 EG_2 BMI = 29.9 ± 2.8 CG BMI = 31.2 ± 2.4	EG_1 = 35 EG_2 = 38 CG = 8	36 weeks 3 / 7	30-45min. HRR 50-80%	EG_1 – dietary regimen EG_2 – aerobic exercise (running on a treadmill and riding a bicycle ergometer) CG - no physical activity	EG_1 » BW ↓ p<0.05 BMI ↓ p<0.05 BFP% ↓ p<0.05 WC ↓ p<0.05 WHR ↓ p<0.05 FFM ↓ p<0.05 VO_{2max} ↑ ¥ EG_2 » BW ↓ p<0.05 BMI ↓ ¥ BFP% ↓ p<0.05 WC ↓ ¥ WHR ¥ FFM ↓ ¥ VO_{2max} ↑ p<0.05 CG » ¥
Messier et al. (2000)	Obese individuals with osteoarthritis	M = 7 F = 17	EG_1 = 69 ± 5 EG_2 = 67 ± 4	n = 24	EG_1 BMI = 38 ± 6 EG_2 BMI = 35 ± 5	EG_1 = 11 EG_2 = 13	12 weeks 3/7	60min. HRR 50-75%	EG_1 - combined training (aerobic walking + weight training exercises) EG_2 - combined training (aerobic walking + weight training exercises) + dietary regimen (nutrition education 60min per week)	EG_2 » EG_1 BW ↓ p=0.01 EG_1 » BW ↓ (1.8 kg) EG_2 » BW ↓ (8.5 kg)

Dunstan et al. (2002)	Obese individuals with type 2 diabetes (postmenopausal women)	M = 16 F = 17	EG_1 67.6 ± 5.2 EG_2 66.9 ± 5.3	n = 90	EG_1 BMI = 31.5 ± 3.7 EG_2 BMI = 32.5 ± 3.8	EG_1 = 16 EG_2 = 13	6 months 3 / 7	55min. 1RM 50–85%	EG_1 – dietary regimen + progressive high intensity weight training exercise (warm-up and cool down on a stationary bicycle and weight training exercises) EG_2 – controlled program which includes 5 min of exercise on the stationary bicycle without weights and static stretching exercises for 30 min	3 months: EG_1» BW ↓ p<0.01 WC ↓ p<0.01 EG_2» BW ↓ p<0.01 WC ↓ p<0.01 6 months: EG_1» BW ↓ p<0.01 WC ↓ p<0.01 BF_{kg} ↓ p<0.01 LBM ↑ p=0.09 EG_2» BW ↓ p<0.01 WC ↓ p<0.01 BF_{kg} ↓ p<0.01 LBM ↓ ¥ EG_1» EG_2 (ГхВ) LBM ↑ p<0.05
Irwin et al. (2003)	Postmenopausal obese individuals	F	CG = 60.6 EG = 61.0	n = 173	EG BMI = 30.5 CG BMI = 30.6	CG = 86 EG = 87	12 months 5 / 7 I-III months- 3 supervised training sessions at a gym and 2 at home IV-XII months – 1 supervised training session in a gym and 4 at home	45min. HR_{max} 40–75%	CG – only minimal intensity stretching exercises were suggested EG – combined training (moderate intensity aerobic training (walking on a treadmill and riding a stationary bicycle) and supervised weight training with walking, aerobics and cycling recommended as home exercises)	EG»CG BW ↓ p=0.01 BMI ↓ p=0.004 WC ↓ p=0.049 HC↓ p=0.003 BF_{kg} ↓ p=0.001 BFP% ↓ p=0.001 SCF ↓ p=0.003 VCF ↓ p=0.045

You et al. (2006)	Postmenopausal obese individuals	F	58 ± 1	n = 45	BMI = 33.0 ± 0.6	EG_1 = 15 EG_2 = 14 EG_3 = 16	20 weeks 3 / 7	EG_2 55min. HRR 45-50% EG_3 30min. HRR 70-75%	EG_1 – dietary regimen EG_2 – dietary regimen + low intensity aerobic exercise EG_3 – dietary regimen + high intensity aerobic exercise	EG_1» BW ↓ p<0.001 BFP% ↓ p<0.001 BF_{kg} ↓ p<0.001 LBM ↓ p<0.001 VO_{2max} ↑ p<0.01 EG_2» BW ↓ p<0.001 BFP% ↓ p<0.001 BF_{kg} ↓ p<0.001 LBM ↓ p<0.001 VO_{2max} ↑ p<0.001 EG_3» BW ↓ p<0.001 BFP% ↓ p<0.001 BF_{kg} ↓ p<0.001 LBM ↓ p<0.001 VO_{2max} ↑ p<0.01
Villareal et al. (2006)	Obese, physically weak individuals	M = 9 F = 18	CG =71.1±5.1 EG =69.4±4.6	n = 27	BMI ≥ 30 CG BMI = 39.0 ± 5.0 EG BMI = 38.5 ± 5.3	CG = 10 EG = 17	26 weeks 3/7	90min	CG – no physical activities EG – dietary regimen + combined training (flexibility exercises + endurance exercises + weight training exercises+ balance exercises)	EG» BW ↓ p<0.001 BF_{kg} ↓ p<0.001 FFM ↓ p=0.04 PPT ↑ p=0.001 VO_{2max} ↑ p=0.001 FSQ ↑ p=0.005 EG»CG BW ↓ p<0.001 BF_{kg} ↓ p<0.001 FFM ↓ ¥ p=0.75 PPT ↑ p=0.001 VO_{2max} ↑ p=0.02 FSQ ↑ p=0.02
O'Leary et al. (2006)	Obese individuals (postmenopausal women)	M = 5 F = 11	63 ± 1	n = 16	BMI = 33.2 ± 1.4	EG = 16	12 weeks 5 / 7	50-60min HR_{max} 60-85%	EG – aerobic exercise program (riding a bicycle, running on a treadmill and stretching)	EG» BW ↓ p<0.0001 BMI ↓ p<0.0001 BF_{kg} ↓ p<0.005 FFM ↑ ¥ TAF ↓ p<0.003 SCF ↓ p<0.03 VCF ↓ p<0.0001

Lambert et al. (2008)	Obese, physically weak individuals	M = 8 F = 8	69 ± 1	n = 16	BMI = 38 ± 6	EG_1 = 8 EG_2 = 8	12 weeks 3 / 7	90min. HR_{max} 75-90% 1RM 65-80%	EG_1 – dietary regimen EG_2 – combined training (aerobic exercise, weight training exercise, flexibility and balance exercises)	EG_1» BW ↓ p=0.001 BMI ↓ p<0.05 BF_{kg} ↓ p<0.05 FFM ↓ p=0.01 EG_2» BW ↓ ¥ BMI ↓ ¥ BF_{kg} ↓ p<0.05 FFM ↑ p=0.03
Frimel et al. (2008)	Obese, physically weak individuals	M = 12 F = 18	70 ± 5	n = 30	EG_1 BMI = 36.9 ± 4.9 EG_2 BMI = 36.7 ± 5.1	EG_1 = 15 EG_2 = 15	24 weeks 3 / 7	90min 1RM 85%	EG_1 – dietary regimen EG_2 – dietary regimen + combined training (flexibility exercises, low intensity aerobic exercises, progressive training with high intensity weight training and balance exercises)	EG_1» EG_2 BW ↓ ¥ BF_{kg} ↓ ¥ FFM ↓ p<0.05 UELBM ↓ p<0.05 LELBM ↓ p<0.05 EG_2» UELBM ↓ ¥ p=0.35
Davidson et al. (2009)	Obese individuals	M = 57 F = 79	M = 67.7 ± 5.1 F = 67.5 ± 5.1	n = 136 study completed by n = 84	M BMI = 30.4 ± 2.7 F BMI = 29.5 ± 3.0	CG = 24 EG_1 = 30 EG_2 = 30 EG_3 = 33	6 months EG_1 3 / 7 EG_2 5 / 7 EG_3 3 / 7	EG_1 20min. HR_{max} 45% EG_2 30min HR_{max} 60-75% EG_3 50min. Aerobic exercise HR_{max} 60-75% Weight training HR_{max} 45%	Seminars on nutrition during the exercise program for all groups of participants CG – no physical activity EG_1 –weight training exercises (1 set of 9 exercises) EG_2 – aerobic exercises (moderate intensity walking on a treadmill) EG_3 – combined training (moderate intensity walking on a treadmill + weight training exercises)	EG_1» CG WC ↓ p<0.05 EG_2» CG TAF ↓ p<0.05 SCF ↓ p<0.05 VCF ↓ p<0.05 EG_2» CG, EG_1 BW ↓ p<0.05 BMI ↓ p<0.05 WC ↓ p<0.05 BF_{kg} ↓ p<0.05 EG_3» EG_1 BW ↓ p<0.05 BMI ↓ p<0.05 BF_{kg} ↓ p<0.05 EG_3» CG, EG_1 WC ↓ p<0.05 TAF ↓ p<0.05 SCF ↓ p<0.05 VCF ↓ p<0.05

Wycherley et al. (2010)	Obese individual with type 2 diabetes	M / F	56.1 ± 7.5	n = 59	CG_1 BMI = 34.8 ± 4.9 CG_2 BMI = 35.6 ± 3.8 EG_1 BMI = 34.9 ± 4.9 EG_2 BMI = 36.6 ± 5.0	CG_1 = 16 CG_2 = 12 EG_1 = 17 EG_2 = 14	16 weeks 3 / 7	45min. 1RM 70–85%	CG_1 – low protein and no fat diet CG_2 – high protein and low fat diet EG_1 – low protein and no fat diet + weight training exercise program EG_2 – high protein and low fat diet + weight training exercise program	EG_1, EG_2, CG_1, CG_2 » BW ↓ p<0.001 WC ↓ p<0.001 BMI ↓ p<0.001 FFM ↓ p<0.001 EG_2» CG_1, CG_2 BW ↓ p<0.05 WC ↓ p≤0.02 BF_{kg}↓ p≤0.02 EG_2» EG_1 BW ↓ ¥ WC ↓ ¥ BF_{kg}↓ p=0.06 FFM ↓ ¥ EG_1, EG_2 » CG_1, CG_2 BW ↓ p=0.02 WC ↓ p<0.01 BF_{kg}↓ p<0.01 BMI ↓ p=0.03 FFM ↓ ¥ CG_2» CG_1 BW ↓ ¥ BF_{kg}↓ p=0.06 FFM ↓ ¥
Villareal et al. (2011)	Obese, physically weak individuals	M = 40 F = 67	CG = 69 ± 4 EG_1 = 70 ± 4 EG_2 = 70 ± 4 EG_3 = 70 ± 4	n = 107 study completed by n = 93	CG BMI = 37.3 ± 4.7 EG_1 BMI = 37.2 ± 4.5 EG_2 BMI = 36.9 ± 5.4 EG_3 BMI = 37.2 ± 5.4	CG = 27 EG_1 = 26 EG_2 = 26 EG_3 = 28	52 weeks 3 / 7	EG_2 and EG_3 90min HR_{max} 65-85% 1RM 65-80%	CG – no physical activity EG_1 – dietary regimen EG_2 – combined training (aerobic exercise + weight training exercise + flexibility and balance exercises) EG_3 – dietary regimen + combined training (aerobic exercise + weight training exercise + flexibility and balance exercises)	EG_2 » CG BW ↓ ¥ BF_{kg}↓ p=0.004 LBM ↑ p<0.001 BMD ↑ p=0.001 EG_3» EG_1 BW ↓ ¥ BFkg ↓ ¥ LBM ↓ p=0.04 BMD ↓ p=0.005 EG_3» EG_2 BW ↓ p<0.001 BF_{kg}↓ p<0.001 LBM ↓ p<0.001 BMD ↓ p<0.001

Foster-Schubert et al. (2012)	Menopausal obese individuals	F	58.0 ± 5.0	n = 439 study completed by 399	BMI = 30.9 ± 4.0	CG = 80 EG_1 = 105 EG_2 = 106 EG_3 = 108	12 months EG_2 , EG_3 5 / 7	≥45min HR_{max} 60-85%	CG – no physical activity EG_1 – dietary regimen EG_2 – moderate to high intensity aerobic exercise EG_3 – dietary regimen + moderate to high intensity aerobic exercise	EG_1 » CG BW ↓ p<0.0001 BFP% ↓ p<0.0001 BMI ↓ p<0.0001 WC ↓ p<0.0001 EG_2 » CG BW ↓ p=0.034 BFP% ↓ p<0.0001 BMI ↓ p=0.01 WC ↓ p=0.0005 LBM ↑ ¥ EG_3 » CG BW ↓ p<0.0001 BFP% ↓ p<0.0001 BMI ↓ p<0.0001 WC ↓ p<0.001 EG_2 » EG_1 LBM ↑ p<0.0001 EG_2 » EG_3 LBM ↑ p<0.003 EG_1 » EG_2 BW ↓ p<0.0001 WC ↓ p<0.004 BFP% ↓ p<0.005 EG_3 » EG_2 BW ↓ p<0.0001 WC ↓ p<0.0001 BFP% ↓ p<0.005 EG_3 » EG_1 BW ↓ ¥ WC ↓ p<0.004 BFP% ↓ p<0.005

Armamento - Villareal et al. (2012)	Obese individuals	M = 40 F = 67	CG = 69 ± 0.8 EG_1 = 70 ±0.8 EG_2 = 70 ±0.8 EG_3 = 70 ±0.8	n = 107	BMI ≥ 30 CG BMI = 37.3 ± 0.9 EG_1 BMI = 37.2 ± 0.9 EG_2 BMI = 36.9 ± 1.1 EG_3 BMI = 37.2 ± 1.0	CG = 27 EG_1 = 26 EG_2 = 26 EG_3 = 28	52 weeks 3/7	EG_2 and EG_3 90min HR_{max} 65-85% 1RM 65-80%	CG – no physical activity EG_1 – dietary regimen EG_2 – combined training (flexibility exercises + aerobic exercises + weight training exercises) EG_3 – dietary regimen + combined training (flexibility exercises + aerobic exercises + weight training exercises)	EG_1, EG_3 » CG, EG_2 BW ↓ p<0.001 CG, EG_2 » BW ¥ EG_3 » LBM ↓ -3.2 ± 0.5% EG_1 » LBM ↓ -5.3 ± 0.7% EG_2 » LBM ↑ 2.4 ± 0.5% EG_1 » LS ↑ p<0.05
Bocalini et al. (2012)	Obese individuals	F = 69	CG_1 = 67 ± 9 EG_1 = 66 ± 4 CG_2 = 63 ± 2 EG_2 = 64 ± 4 CG_3 = 62 ± 1 EG_3 = 62 ± 2	n = 69	CG_1 and EG_1 BMI = 18.5 – 24.9 CG_2 and EG_2 BMI = 25.0 – 29.9 CG_3 and EG_3 BMI >30.0	CG_1 = 9 EG_1 = 18 CG_2 = 10 EG_2 = 14 CG_3 = 9 EG_3 = 9	12 weeks 3/7	50min HR_{max} 70%	CG_1, CG_2, CG_3 – no physical activities EG_1, EG_2, EG_3 -Circuit training (aerobic warm-up, weight training exercises and stretching exercises)	CG_1, CG_2, CG_3, EG_1, EG_2» BW ¥ BF_{kg} ¥ BFP% ¥ LBM ¥ EG_3» CG_3 BW ↓ p<0.05 BF_{kg} ↓ p<0.05 BFP% ↓ p<0.05 LBM ↑ p<0.05 BMI ↓ p<0.05

Amati et al. (2013)	Obese individuals	M = 26 F = 38	67 ± 0.5	n = 64	BMI = 30.7 ± 0.4	EG_1 = 11 EG_2 = 36 EG_3 = 17	16 weeks 3-5/7	45min VO_{2max} 50-75%	EG_1 – dietary regimen EG_2 – moderate intensity aerobic exercises EG_3 - moderate intensity aerobic exercises + dietary regimen	EG_1» BMI ↓ p<0.05 BF_{kg} ↓ p<0.05 LBM ↓ p<0.05 VO_{2max} ↑ ¥ EG_2» BMI ↓ p<0.05 BF_{kg} ↓ p<0.05 LBM ↑ ¥ VO_{2max} ↑ p<0.05 EG_3» BMI ↓ p<0.05 BF_{kg} ↓ p<0.05 LBM ↓ p<0.05 VO_{2max} ↑ p<0.05
Romero-Arenas et al. (2013)	Obese individuals and overweight individuals	M/F	61.6 ± 5.3	n = 37	EG_1 BMI = 29.7 ± 4.1 EG_2 BMI = 30.2 ± 6.0 CG BMI = 29.9 ± 5.8	EG_1 = 16 EG_2 = 14 CG = 7	12 weeks 2 / 7	EG_1 35-47min. 1RM 85-90% EG_2 45-87min. 1RM 85-90%	EG_1 – circuit training with high intensity weight training exercises EG_2 – classic weight training CG – no physical activity Nutrition advice	EG_1» IS ↑ p<0.001 LBM ↑ p<0.001 BMD ↑ p=0.025 BF_{kg} ↓ p=0.011 EG_2» IS ↑ p<0.001 LBM ↑ p=0.025 BMD ↑ p=0.018 EG_1, EG_2» CG IS ↑ p<0.03 EG_1» CG BF_{kg} ↓ p=0.039

Beavers et al. (2014)	Obese indivduals with osteoarthritis of the knee	M = 75 F = 209	66.0 ± 6.2	n = 284	EG_1 BMI = 33.5 ± 3.7 EG_2 BMI = 33.2 ± 3.6 EG_3 BMI = 33.4 ± 3.7	EG_1 = 95 EG_2 = 88 EG_3 = 101	18 months 3 / 7	60min	EG_1 – combined training (walking and weight training exercises) EG_2 – dietary regimen EG_3 – dietary regimen + combined training (walking and strength exercises)	EG_1» BW ↓ p<0.01 EG_2» BW ↓ p<0.01 EG_3» BW ↓ p<0.01 EG_2, EG_3» EG_1 BMD ↓ p<0.01
Ryan & Harduarsingh -Permaul (2014)	Postmenopausal obese individuals	F	50 - 76	n = 65	EG_1 BMI = 32 ± 1 EG_2 BMI = 34 ± 1	EG_1 = 43 EG_2 = 22	6 months EG_1 3 / 7	60min HRR 50-85%	EG_1 – dietary regimen + aerobic exercise on a treadmill EG_2 – dietary regimen	EG_1» BW ↓ p<0.001 BMI ↓ p<0.001 WC ↓ p<0.001 WHR ¥ BFP% ↓ p<0.001 BF_{kg} ↓ p<0.001 LBM ↓ p<0.05 FFM ↓ p<0.05 TAF ↓ p<0.001 EG_2 » BW ↓ p<0.001 BMI ↓ p<0.001 WC ↓ p<0.001 WHR ¥ BFP% ↓ p<0.001 BF_{kg} ↓ p<0.001 LBM ↓ p<0.01 FFM ↓ p<0.01 TAF ↓ p<0.001

Villareal et al.(2017)	Obese, physically weak individuals	M = 57 F = 103	CG = 70 ± 5 EG_1 = 70 ± 4 EG_2 = 70 ± 5 EG_3 = 70 ± 5	n = 160	BMI ≥ 30 CG BMI = 37.3 ± 0.9 $E\Gamma_1$ BMI = 35.9 ± 4.4 $E\Gamma_2$ BMI = 36.7 ± 5.8 $E\Gamma_3$ BMI = 35.8 ± 4.5	CG = 40 EG_1 = 40 EG_2 = 40 EG_3 = 40	26 weeks 3/7	EG_1 60min. HR_{max} 65-85% EG_2 60min. 1RM 65-85% EG_3 75-90min. HR_{max} 65-85% 1RM 65-85%	CG – instructions regarding dietary regimens and no physical activity EG_1 – dietary regimen + aerobic training EG_2 – dietary regimen + weight training exercises EG_3 – dietary regimen + combined training (aerobic + weight training exercises)	EG_1, EG_2, EG_3 » CG PPT ↑ p<0.001 EG_3 » EG_1 PPT ↑ p=0.01 EG_3 » EG_2 PPT ↑ p=0.02 EG_1, EG_2 » EG_3 VO_{2max} ↑ p<0.001 EG, EG_3 » EG_1 MS ↑ p<0.001 EG_1, EG_2, EG_3 » BW ↓ 9% CG » BW ↓ ¥ EG_1» EG_2, EG_3 LBM ↓ p<0.05 BMD↓ p<0.05

Legend: M - male; F - female; X - unavailable; n – number of participants; EG-experimental group; CG- control group; PPT – (Physical Performance Test); FSQ – (Functional Status Questionnaire); p – level of statistical significance; ↑- improvement/increase; ↓ - decrease; ‡ - moderate statistical significance; ¥ - no statistical significance; » - differences between the initial and final measurement; (GxT) – significant effect of interaction between the groups and time; BMI – body mass index (kg/m^2); HR_{max} – maximal heart rate frequency; HRR – resting heart rate; EG»CG – differences in favor of the experimental group in relation to the control group following the exercise program; VO_{2max} – maximum oxygen uptake (ml/kg/min); MS – muscle strength; BW- body weight; LBM – lean body mass including essential body fat (kg); UELBM – upper extremities weight without body mass (kg); LELBM – lower extremities weight without body mass (kg); BMD – bone mineral density (g/cm^2); 1RM – 1 repetition maximum; LS – (sclerostin levels); BF_{kg} – amount of body fat (kg); FFM – fat free mass (kg); BFP% - percentage of body mass; WC – waist circumference (cm); HC- hip circumference; WHR – waist to hip ratio; TAF – total abdominal fat (g/cm^2); SCF – subcutaneous fat tissue (g/cm^2); VCF – visceral fat (g/cm^2); IS – isokinetic strength.

DISCUSSION

The research results whose aim was the evaluation of the effects of PE on the changes in body composition and decrease in the body weight among elderly obese individuals are shown in table form (Table 1). They indicate that the most prevalent programs were those that included the simultaneous use of a combined means of exercise (aerobic exercises, weight training exercises, flexibility and balance exercises) and a dietary regimen (Messier et al., 2000; Villareal, Banks, Sinacore, Siener, & Klein, 2006; Frimel, Sinacore, & Villareal, 2008; Davidson et al., 2009; Villareal et al., 2011; Armamento-Villareal et al., 2012; Beavers et al., 2014; Villareal et al., 2017).

The effect of exercise on obesity, on the changes in body weight and other anthropometric data among the elderly, isolated by a combination of exercise programs without a reduction in food intake, was analyzed in seven studies (Messier et al., 2000; Irwin et al., 2003; Lambert, Wright, Finck, & Villareal, 2008; Villareal, et al., 2011; Armamento-Villareal et al., 2012; Bocalini et al., 2012; Beavers et al., 2014). The authors of six studies relied on aerobic exercises in combination with a dietary regimen to induce changes in one of the groups of obese participants (You et al., 2006; Amati, Dubé, Shay, & Goodpaster, 2008; Davidson, et al., 2009; Foster-Schubert et al., 2012; Ryan & Harduarsingh-Permaul, 2014; Villareal et al., 2017), while in four of the studies only an aerobic exercise program was used (Womack et al., 2000; O'Leary et al., 2006; Amati et al., 2008; Foster-Schubert et al., 2012). A combination of a dietary regimen and weight training exercises was prescribed to a group of participants in four studies (Dunstan et al., 2002; Davidson et al., 2009; Wycherley, Noakes, Clifton, Cleanthous, Keogh, & Brinkworth, 2010; Villareal, et al., 2017), and only a weight training exercise program was used in one of the studies (Romero-Arenas et al., 2013).

Seminars on proper nutritional intake during exercise, dietary regimens for the reduction of body weight, and various types of supplements, as well as consultations with nutritionists, were provided to a group of participants in 12 of the included studies (Womack et al., 2000; You et al., 2006; Amati et al., 2008; Frimel et al., 2008; Lambert et al., 2008; Wycherley et al., 2010; Villareal et al., 2011; Armamento-Villareal et al., 2012; Foster-Schubert et al., 2012; Beavers et al., 2014; Ryan & Harduarsingh-Permaul, 2014; Villareal et al., 2017).

The total number of participants included in this systematic review was 2029. In five of the studies the participants were only women (Irwin et al., 2003; You et al., 2006; Bocalini et al., 2012; Foster-Schubert et al., 2012; Ryan & Harduarsingh-Permaul, 2014), that is 791 female participants in total, while in one of the studies only male participants took part, that is 81 male participants (Womack et al., 2000). The remaining 14 studies had mixed samples of participants (n=1157).

The smallest number of obese participants in the experimental group which took part in combined training (aerobic exercises, weight training exercises, flexibility and balance exercises) was eight (Lambert et al., 2008) and the largest was 108, in a study which at the same time was also the study which included the largest sample of participants (n=439). In this study, a group of obese women took part in a combined dietary regimen and moderate to high intensity aerobic exercise (Foster-Schubert et al., 2012).

The duration of the studies differed and ranged from an interval of 12 weeks (Messier et al., 2000; O'Leary et al., 2006; Lambert, et al., 2008; Bocalini et al., 2012; Romero-

Arenas et al., 2013) which also represents the most frequently used duration of the applied program, to 18 months (Beavers et al., 2014). The most frequent weekly rate of training sessions was applied in 16 of the studies, and included three training sessions per week. The shortest duration of individual training sessions was 20 minutes of aerobic exercise (Davidson et al., 2009), and the longest 90 minutes of combined aerobic and weight training exercises (Villareal et al., 2006; Frimel et al., 2008; Lambert et al., 2008; Villareal et al., 2011; Armamento-Villareal et al., 2012).

The intensity of the exercise in the analyzed studies differed and ranged from 40% to 85% of maximum heart rate (HR_{max}) and from 45% to 80% of resting heart rate during aerobic and combined training, while intensity during weight training ranged from 45% to 90% of 1RM. The maximum intensity of the aerobic exercise as part of combined training ranged from 70% to 90% of HR_{max} (Lambert et al., 2008), while in one of the studies which focused on the effects of circuit and classical weight training, the maximum intensity ranged from 85% to 90% of 1RM (Romero-Arenas et al., 2013).

The systematic review of the measurements of the included parameters identified multiple effects of the applied exercise programs on the obesity levels of the elderly in the form of a reduction in body weight. The best statistically significant effects ($p<0.001$) on the reduction in body mass were achieved in studies with a longer duration of the experimental treatment from 26 and 52 weeks, the simultaneous application of a dietary regimen and combined program of aerobic and weight training exercises (Villareal et al., 2006; Villareal et al., 2011; Armamento-Villareal et al., 2012). In addition, a somewhat lower effect on the decrease in body weight was determined for the programs which included a dietary regimen for the reduction of energy intake through food in combination with aerobic exercises of moderate and high intensity over a longer period of time, from 6 and 12 months (You et al., 2006; Foster-Schubert et al., 2012), then independently applied programs of aerobic exercise with a greater weekly frequency (O'Leary et al., 2006), as well as training sessions which included weight training of a moderate to high intensity in combination with a dietary regimen (Dunstan et al., 2002; Wycherley et al., 2010). The results of this study confirmed the claims of authors of previous studies (Villareal, Apovian, Kushner, & Klein, 2005; Jakičić & Otto, 2006), that exercise without a reduction in food intake is less effective when it comes to the decrease in body mass.

The effect of a combined program of exercise with changes in the dietary regimen led to a decrease in the BMI, with a statistically significant difference identified in studies whose PE program lasted for 6 months or longer (Irwin et al., 2003; Davidson et al., 2009; Foster-Schubert et al., 2012; Ryan & Harduarsingh-Permaul, 2014). A significant decrease in the values of BMI was achieved in studies which included aerobic exercise programs without dietary restrictions, but of a shorter duration, of 12 and 16 weeks, and a frequency of exercise of five training sessions a week (O'Leary et al., 2006; Amati et al., 2008).

By comparing the results of the applied programs, the greatest statistically significant reduction ($p<0.001$) in the amount of BF in kg (BF_{kg}), was noted in studies with the simultaneous application of a dietary regimen and combined aerobic and weight training exercises, where the exercise program lasted over a longer period of time, 26 weeks and 52 weeks (Villareal et al., 2006; Villareal et al., 2011), as well as over aerobic exercise programs combined with a dietary regimen which lasted for longer periods of time, 20 weeks and 6 months (You et al., 2006; Ryan & Harduarsingh-Permaul, 2014). The amount of BF in the body decreased in the studies with isolated programs of aerobic and weight training

exercises, without changes in the dietary regimen, but with more training sessions per week. However, these changes were statistically smaller than the ones that occurred in combination with a dietary regimen (Irwin et al., 2003; O'Leary et al., 2006). The greatest noted decrease in percentage of BF (BFP%), compared to the control group of participants, was determined for aerobic exercise programs which lasted for a period of 12 months, in combination with a reduction in food intake (Foster-Schubert et al., 2012).

The effects of the exercise programs, when it comes to the results recorded for LBM, which also included essential BF, indicate that the increase occurred in the studies which used a combination of aerobic and weight training exercises with no dietary regimen (Villareal et al., 2011; Armamento-Villareal et al., 2012; Bocalini et al., 2012). The simultaneous application of combined exercise programs and dietary regimens in most cases leads to a decrease in LBM (Armamento-Villareal et al., 2012; Villareal et al., 2011), while weight training exercises of high intensity combined with a dietary regimen or without a change in diet contribute to an increase in the LBM among obese elderly individuals (Dunstan et al., 2002; Romero-Arenas et al., 2013).

Based on the analysis of the results of the compiled studies, the claims of previous authors could be confirmed (Yassine et al., 2009). The application of an exercise program without a change in the dietary regimen for a period of 12 or more weeks could lead to a slight decrease in body mass, that is, the amount of BF in the body and an increase in fat free and LBM among obese elderly individuals (Lambert et al., 2008; Romero-Arenas et al., 2013). In addition, it should be pointed out that a much greater effect on body composition of obese elderly individuals is achieved by a combined exercise program which includes both weight training exercises and aerobic exercises, with the simultaneous application of dietary regimen, which is reflected in a decrease in energy intake through food and adequate protein intake, in accordance with the claims of previous studies (Villareal et al. 2005; Jakičić & Otto, 2006; Weinheimer et al., 2010; Mathus-Vliegen, 2012; Miller et al., 2013).

CONCLUSION

The research results indicate that there are many studies which analyze the effects of various PA programs either independently or in combination with dietary regimens on the health and obesity levels among the elderly, of an average age of 55 to 80.

The analysis of the compiled studies has confirmed the existence of the positive effect of PA on obesity among the elderly, and led to the conclusion that a combined program of aerobic, weight training, flexibility and balance exercises for a period of at least 12 weeks leads to a mild decrease in body mass and amount of fat mass in the body, while maintaining and increasing LBM, mostly in the form of muscle tissue. However, a much greater effect on the decrease on BF was achieved with the simultaneous application of a combined program of PE and dietary regimens for a period of 6 months.

Finally, following a summation of all the results, we could conclude that PA is an effective means of reducing obesity, and so its use is recommended among the population of the elderly.

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UTICAJ FIZIČKE AKTIVNOSTI NA GOJAZNOST STARIH OSOBA - SISTEMATSKO PREGLEDNO ISTRAŽIVANJE

Cilj ovog preglednog istraživanja bio je da se utvrde efekti fizičke aktivnosti (PA) na gojaznost starih osoba. Za pregled postojećih istraživanja o efektima PA na gojazne stare osobe, pretraživane su elektronske baze PubMed, SCIndeks, PEDro, J-GATE, DOAJ i Google Scholar. Analizom i primenom zadatih kriterijuma, konačna analiza obuhvatila je 20 studija i potvrđen je pozitivan uticaj PA na gojaznost starih osoba. Najveći efekat na smanjenje telesne mase postignut je istovremenom primenom kombinacije programa vežbanja i režima ishrane u trajanju od 6 meseci. Zaključeno je da kombinovani programi aerobika, treninga sa opterećenjem, vežbi fleksibilnosti i ravnoteže tokom perioda od najmanje 12 nedelja dovode do blagog smanjenja telesne mase i količine masne mase, istovremeno održavajući i povećavajući bezmasnu telesnu masu, uglavnom u formi mišićnog tkiva. PA je efikasno sredstvo za smanjenje gojaznosti, pa se stoga preporučuje njena upotreba među starim osobama.

Ključne reči*: fizička vežba, starenje, sastav tela, indeks telesne mase, gubitak mase tela*

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Research article

ECONOMIC EFFECTS OF INJURIES IN ELITE SOCCER PLAYERS WITH REGARD TO ANKLE INJURY

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Abstract. *The main aim of the current research is to determine the differences and correlations of sport seasons and economic statistics between the highest paid soccer players in the world, with an ankle injury in addition to other injuries and without an ankle injury. By comparing highest paid soccer players in the world (N=95), i.e., a sub-sample of players with an ankle injury (N=44), and a sub-sample of players without an ankle injury (N=51), it is possible to conclude that significant differences were not found in the variables of age, market value, the number of matches completed, the number of goals scored and the number of assists, as well as in the derived variables of the value of one player's day and the value of one match. In the basic variables the number of days missed due to injuries (222.61±165.61 vs 124.98±110.59), the number of seasons with injuries (5.68±2.23 vs 4.53±2.73) and the number of matches missed due to injuries (35.32±28.07 vs 20.12±19.2), as well as in the derived variables of number of days missed due to injuries per year (40.4±29.33 vs 27.16±18.18), number of games missed due to injuries per year (6.23±3.83 vs 4.32±3.21), value of days missed due to injuries (£7,627±£5,898 vs £5,070±£3,634) and the value of matches missed due to injuries (£13,134±£12,461 vs £9,276±£9,158), statistically significant differences were determined. All determined values were higher in the sub-sample of players who, in addition to other injuries, suffered from an ankle injury as well. In the multivariate exploration of the structure of the basic research variables, the results obtained indicate a latent space that had an interpretable three-dimensional structure. The structure of the space indicated a functionally independent relationship between the frequency and intensity of injury, on the one hand, and the chronological age, the value of the transfer and the player's efficacy on the other. It can be concluded that*

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sports injuries, and ankle injuries especially in elite soccer players, have significant economic reprisals.

Key words: *Sports Injuries, Ankle Sprain, Economic Consequences of Injury*

INTRODUCTION

Engaging in sports activities is also associated with an increased incidence of injuries, among which the ankle injury is the most common. Movements involving the ankle osteoarticular and muscular structures are the basis of competitive and training activities in most sports and sports disciplines, such as football, basketball, volleyball, handball, athletics, etc. (McKay, Goldie, Payne, & Oakes, 2001; Anandacoomarasamy & Barnsley, 2005; Beynnon, Vacek, Murphy, Alosa, & Paller, 2005; Hubbard & Hicks-Little, 2008; Achenbach et al., 2018).

Ankle injury occurs in three modalities: stretching, partial and complete rupture of at least one of the ligaments that stabilize the ankle structures and provide proprioceptive information (Doherty et al., 2014; Gribble et al., 2016a, 2016b). Repeated joint injuries can lead to functional disorders in the form of joint instability, loss of proprioception, significant impairment of locomotor potentials, early degenerative processes on the bones and chronic pain. It has been shown that only about one-fourth of injured patients recover fully, without pain, swelling and decreased functional potential in the ankle structures. Other injured individuals have problems that persist for at least two years after the injury (Cruz, Oliveira, & Silva, 2020).

In football, lower extremity injuries occur in 67% to 88% of cases, with ankle injury being most common in both men and women (Östenberg & Roos, 2000; Waldén, Hägglund, & Ekstrand, 2005, 2007; Dvorak, Junge, Grimm, & Kirkendall, 2007; Hägglund, Walden, & Ekstrand, 2007; Pierpoint, LaBella, Collins, Fields, & Comstock, 2018).

An analysis of 1524 injuries in 637446 people training football revealed the most frequent injuries during the competition and an incidence of 4.77 injuries per 1000 people/competitions, while this incidence is significantly lower in training activities and is 1.37 per 1000 people/training (Yard, Schroeder, Fields, Collins, & Comstock, 2008).

Injuries are the most common during matches, and are 100% to 300% more frequent than training injuries (Poulsen, Freund, Madsen, & Sandvej, 1991; Dvorak & Junge, 2000). The highest number of sports injuries, about 50%, are a consequence of excessive load, i.e., of disproportion between the athlete's ability and what is expected from him (Krstić & Stamatović, 2018). According to the available data, in football the incidence of injury increases with increasing fatigue in players. Thus, injury in the second half of the match is more frequent than injury in the first. In addition, injuries were found to be reduced in the first 15 minutes of the match, while increasing markedly in the last 15 minutes of the second half (Dvorak et al., 2007; Tscholl et al., 2007; Tscholl, O'Riordan, Fuller, Dvorak, & Junge, 2000).

Today, especially in the field of top competitive sports, the phenomenon of injury has its very pronounced economic component. The amounts exchanging hands during transfers, as well as of other athletes' incomes in the most lucrative sports, indicate the extremely high "prices" of injuries that prevent these athletes from participating in the competition system. Every day of absence from training has a high price, and especially high prices for

absenteeism from matches and competitions, for which fans, donors and sponsors, as well as the entire related industry of goods and services, participate in the sports organization's costs.

Failure to appear by an elite soccer player, basketball player, tennis player, etc. automatically leads to a decline in interest in a sporting event and results in significantly lower revenues than expected.

The financial implications of ankle injury are vividly illustrated by the fact that the estimated economic burden created by 250000 annual sprains in US can amount to $2-4 billion annual costs, thus creating an economic burden on the global health care systems (Waterman, Owens, Davey, Zacchilli, & Belmont Jr, 2010). These primary, immediate costs of injury should be accompanied by the costs of osteoarthritis medical care, which occurs frequently and develops over the life of previously injured athletes (Englund, Roos, & Lohmander, 2003; Roos, 2005; Ezzat, Brussoni, Whittaker, & Emery, 2018).

The main aim of the current research is to determine differences and correlations between sport season and economic statistics between the highest paid soccer players in the world, with an ankle injury in addition to other injuries and without an ankle injury.

METHODS

The research was conceived as an exploratory cross-sectional study with parallel groups on an initial sample, consisting of the 100 highest paid soccer players in the world (Transfermarkt, 2019). As all the required information was not available for 5 soccer players, and the basic sample was reduced to 95 respondents. The study sub-samples were formed under the criterion of ankle injury: a sub-sample of soccer players with an ankle injury in addition to other injuries (SS1, N=44) and a sub-sample of soccer players who had not injured their ankle (SS2, N=51). The basic and derived variables in the study are presented in Table 1.

Table 1 Basic and derived variables observed in the research

Basic variables	Abbreviation
Age	Age
Market Value	Market Value (£)
Match Played	Match
Goals Scored	Goals
Assists	Assists
Number of Days Missed Due to Injuries	Days_Inj
Number of Seasons with Injuries	Years_Inj
Number of Matches Missed Due to Injuries	Match_Inj
Derived variables	
Number of Days Missed Due to Injuries per Year	Days_Inj/Year
Number of Matches Missed Due to Injuries per Year	Match_Inj/Year
Value of One Player's Day	Day_Val (£)
Value of One Match	Match_Val (£)
Value of Days Missed Due to Injuries	Inj_Day_Val (£)
Value of Matches Missed Due to Injuries	Inj_Match_Val (£)

All data were processed using descriptive, inferential and multivariate statistical methods. Descriptive statistical analysis determined the minimum and maximum values, mean values and standard deviations for the baseline sample, as well as for the sub-samples of the survey. Testing for significance of the differences between the sub-samples in the observed variables was performed by Mann Whitney's U-test. In the domain of multivariate analysis, factor analysis of the manifest space of the observed, basic variables was performed using the principal components method. A number of significant factors were determined according to the Kaiser Guttman criterion, and the initial factor solution was brought to the most interpretable form by rotation according to the Varimax criterion.

RESULTS

Table 2 Results of the descriptive statistics and Mann Whitney U-Test

Variables	Basic sample (n=95)			With an ankle injury (n=44)			Without an ankle injury (n=51)			M-W
	Min	Max	Mean ±SD	Min	Max	Mean ±SD	Min	Max	Mean ±SD	p
Age	18	34	25.13 ±2.99	20	34	25.3 ±2.9	18	32	24.98 ±3.1	0.780
Market Value (£)	45.000	180.000	69.537 ±27.149	45.000	180.000	70.875 ±32.292	45.000	144.000	68.382 ±22.046	0.407
Match	12	50	35.79 ±6.22	17	50	35.75 ±6.45	12	45	35.82 ±6.08	0.967
Goals	0	34	8.29 ±8.28	0	31	8.8 ±8.71	0	34	7.86 ±7.94	0.526
Assists	0	19	5.73 ±4.96	0	19	6.11 ±4.86	0	19	5.39 ±5.06	0.315
Days_Inj	3	825	170.2 ±146.45	15	825	222.61 ±165.61	3	499	124.98 ±110.59	0.001*
Years_Inj	1	14	5.06 ±2.56	1	10	5.68 ±2.23	1	14	4.53 ±2.73	0.008*
Match_Inj	0	139	27.16 ±24.79	4	139	35.32 ±28.07	0	94	20.12 ±19.2	0.001*
Days_Inj/Year	1	165.5	33.29 ±24.76	9.5	165.5	40.4 ±29.33	1	90.33	27.16 ±18.18	0.017*
Match_Inj/Year	0	16.33	5.21 ±3.62	1.71	16.25	6.23 ±3.83	0	16.33	4.32 ±3.21	0.012*
Day_Value (£)	123	493	191 ±£74	123	493	194 ±£88	123	395	187 ±£60	0.407
Match_Value (£)	1.071	5.870	2.007 ±£902	1.071	5.586	2.022 ±£919	1.125	5.870	1.993 ±£896	0.797
Inj_Day_Value (£)	123	29.441	6.254 ±£4.958	1.171	29.441	7.627 ±£5.898	123	15.592	5.070 ±£3.634	0.022*
Inj_Match_Value (£)	0	71.690	11.063 ±£10.926	2.250	71.690	13.134 ±£12.461	0	45.500	9.276 ±£9.158	0.029*

Legend: All currency amounts are shown in £ 1,000;
* - statistically significant difference set at the level $p \leq 0.05$

By comparing the sub-samples of the research of soccer players who, besides other injuries, had an ankle injury with a sub-sample of soccer players who had not sustained this type of injury (Table 2), it can be concluded that no significant differences were found in the basic variables Age, Market Value (£), Matches Played, Goals Scored and Assists. For this reason, no statistically significant difference was recorded in the variables derived from the Value of One Player's Day (Day Value £) and the Value of One Match (Match Value £).

In the basic variables, the Number of Days Missed Due to Injuries (Days_Inj, 222.61±165.61 vs 124.98±110.59), the Number of Seasons with Injuries (Years_Inj, 5.68±2.23 vs 4.53±2.73) and the Number of Matches Missed Due to Injuries (Match_Inj, 35.32±28.07 vs 20.12±19.2), statistically significant differences between the research sub-samples were determined, and in the direction of higher value in the sample of players who, in addition to other injuries, had injuries to the ankle. These differences also produced statistically significant differences in the derived variables: Number of Days Missed Due to Injuries per Year (Days_Inj/Year, 40.4±29.33 vs 27.16±18.18), Number of Matches Missed Due to Injuries per Year (Match_Inj/Year, 6.23±3.83 vs 4.32±3.21), Value of Days Missed Due to Injuries (Inj_Day_Value £, 7,627±5,898 vs £5,070±£3,634) and Value of Matches Missed Due to Injuries (Inj_Match_Value £, £13,134±£12,461 vs £9,276±£9,158). In the case of the derived variables, all determined values were higher for the sub-sample of athletes who, in addition to other injuries, had an ankle injury.

Table 3 Factor analysis results

Variables	Factor loads		
	1. factor	2. factor	3. factor
Age	0.382	0.039	0.808*
Market value (£)	0.138	0.794*	0.043
Matches	-0.473	0.252	0.627*
Goals	0.059	0.865*	0.146
Assists	-0.019	0.837*	0.059
Days_Inj	0.936*	0.044	0.011
Years_Inj	0.766*	0.163	0.397
Match_Inj	0.951*	0.080	-0.022
AIGEN	3.008	2.143	1.020
VARIANCE	0.345	0.272	0.154
CUMULATIVE	0.345	0.617	0.771

Legend: * - *salient value*

The inter-functional relationships between the 8 observed variables, which are related to selected indicators of economic aspects of injuries in the highest paid soccer players, common to the basic sample, were determined by a correlation analysis (Table 3). Due to the possible effect of nonspecific and error factors on the indicators analyzed, factorization of the correlation matrices of the basic variables was performed in order to obtain a parsimony structure, which would retain all significant functional relationships, but now decontaminated by the influence of the error factors. In this sense, the factor analysis was performed using the principal components method.

Only the basic variables were retained for analysis because inclusion of the derived variables, due to their linear relationship with the variables from which they were derived, would lead to the collapse of the correlation matrix that was subject to factorization.

Within the space defined by 8 observed (manifest) variables, a factor analysis was conducted, the results of which support the latency of 3 latent variability generators, which can be interpreted as the basic dimensions of the analyzed space. The extracted dimensions are responsible for 77.1% of the total variance registered (Table 3).

In the latent dimension model of the analyzed space, the first Varimax factor extracted 34.5% of the total registered variance (Table 3). The most promising values were projected on this factor by three manifest variables: Number of Days Missed Due to Injuries (Days_Inj, 0.936), Number of Seasons with Injury (Years_Inj, 0.766), and Number of Matches Missed Due to Injuries (Matches_Inj, 0.951). In addition to the above variables, there were statistically significant but non-salient projections of the Matches Played (-0.473) and Age (0.382) variables on this factor. The structure of the variables that were saturated with this factor speaks to the frequency of injury to the soccer player, and thus can be interpreted. It is of interest to note certain functional relationships with the number of matches played, which are negative, i.e. more frequent injury is associated with fewer games played in the season, while more frequent injury in a certain functional relationship is of lower intensity for the age of the soccer player. So, older athletes have a slightly increased likelihood of injury, which will exclude them from the games.

In the model of latent dimensions of the analyzed space, the second Varimax factor extracted 27.2% of the total registered variance (Table 3). The most promising values were projected on this factor by three manifest variables: Market Value £ (0.794), Goals scored (0.865) and Assists (0.837). The construction of this factor points to strong functional links that describe the effectiveness of the soccer player's performance, estimated by the goals scored, or assists from which the goals came, which is related to the market value of the players. For these reasons, the factor can be interpreted as a dimension of the player's efficiency.

In the latent dimension model of the analyzed space, the third Varimax factor extracted 15.4% of the total registered variance (Table 3). The most promising values were the manifest variables Age (0.808) and Matches played (0.627). In addition to the above variables, this factor had a statistically significant but non-salivary projection and the variable Number of Seasons with Injuries (Years_Inj, 0.397). Variables saturated with the third extracted factor, with their functional connections, indicate a higher number of matches played in the season by older players. This link is in support of the conclusion that older, and therefore more experienced players, form the framework of strategic and tactical solutions coaches devise with their team. The sporadic relationship with the variable related to the frequency of injury is due to the previously discussed functional relationships in the structure of the first extracted factor. Finally, this latent dimension of the analyzed space can be interpreted as a factor of performing experience.

DISCUSSION

In relation the descriptive statistical analysis and the analysis of quantitative differences between the sub-samples of soccer players who have or do not have ankle injuries, it should be pointed out that the ankle injury is not in the function of chronological age, or in the function of the athletes' performance efficiency, but that significantly different indicators register abstinence from training and competition with soccer players who injure their ankle, relative to other injuries that athletes sustained. Namely, when the ankle is injured, there is a significantly longer time interval of absence from the sports grounds for an athlete. This data, in conjunction with the fact that observational sub-models do not differ significantly in revenue and athlete performance indicators estimated by the number of goals scored and assists provided, indicates a manifestation of statistically significant differences in financial losses, both in terms of lost training days and in value lost by matches missed.

These results are in conflict with the results of a study in which the length of being engaged in soccer, which is related to the quality of the league in which the athletes perform, has a significant impact on the incidence of injury. These results support the conclusion that long-term soccer involvement has been reduced by a decreased risk of injury by 38% to 48% (Poulsen et al., 1991). Disagreement was observed with respect to research findings in which the age of soccer players was isolated as one of the factors that significantly influence the incidence of injury (Kucera, Marshall, Kirkendall, Marchak, & Garrett Jr, 2005). Research findings have indicated a higher likelihood of injury among older athletes, which has not been observed in the female population (Faude, Junge, Kindermann, & Dvorak, 2005).

This discrepancy can be explained by the pronounced homogeneity of the sample analyzed in this study. Specifically, it is expected that extending the survey sample to populations of lower quality players could produce different results.

According to some authors, the severity of injury can be estimated by the number of days absent from training and competition (Fuller et al., 2006). Thus, injuries not preventing athletes from participating in training and competition are treated as minor. Injuries that disable soccer players in their activities for one to three days are considered to be minimal. There are moderate injuries that remove players from the field from 4 up to 7 days. Medium-weight injuries qualify pathological conditions that disable players from 8 to 28 days, while injuries that prevent players from training and competing for more than 28 days are considered severe. Of the total injuries of players of all ages, they account for 10% to 25% of the total number of injuries.

Top-level competitive sports have become one of the most important leisure activities, during which spectators, fans and devotees follow sports events around the world (Andreff, 2015; McColl-Kennedy & Fetter, 2001). Media penetration and the presence of sports content provides access to the widest range of potential consumers, which is why advertising resources in electronic and print media reach astronomical values (McColl-Kennedy & Fetter, 2001; Lefever, 2012).

CONCLUSION

It is possible to conclude that factor analysis of selected indicators of economic aspects of injury among the highest paid soccer players in the world produced an inter-stable structure of space determined by three basic dimensions. It is of interest to the research that the frequency of injury has no significant functional links with the experience and player effectiveness of the highest paid soccer players in the world, but is the result of the operation of latent generators of variability independent of players' income, their chronological and sports' performance age.

Finally, the research findings indicate the pronounced economic importance of injuring elite soccer players, with ankle injury being an additional factor that significantly increases negative economic indicators of injury.

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EKONOMSKI EFEKTI POVREDA VRHUNSKIH FUDBALERA U ODNOSU NA POVREDU SKOČNOG ZGLOBA

Glavni cilj aktuelnog istraživanja je da se utvrde razlike i korelacije u statistici sportske sezone i ekonomskoj statistici između najplaćenijih fudbalera na svetu, sa povredom skočnog zgloba pored ostalih povreda i bez povrede skočnog zgloba. Upoređujući najbolje plaćene fudbalere na svetu (N=95), tj. subuzorak igrača sa povredom skočnog (N=44), sa subuzorkom igrača bez povrede skočnog zgloba (N=51), moguće je zaključiti da značajne razlike nisu konstatovane u varijablama starosti, tržišne vrednosti, broja odigranih utakmica, broja postignutih golova i broja asistencija, kao ni u izvedenim varijablama vrednosti jednog igračkog dana i vrednosti jedne utakmice. U osnovnim varijablama broja propuštenih dana zbog povreda (222.61±165.61 vs 124.98±110.59), broja sezona sa povredom (5.68±2.23 vs 4.53±2.73) i broja propuštenih utakmica zbog povreda (35.32±28.07 vs 20.12±19.2), kao i u izvedenim varijablama broja propuštenih dana zbog povreda godišnje (40.4±29.33 vs 27.16±18.18), broja propuštenih utakmica zbog povreda godišnje (6.23±3.83 vs 4.32±3.21), vrednost propuštenih

dana zbog povrede (£7,627±£5,898 vs £5,070±£3,634) i vrednost propuštenih utakmica zbog povrede (£13,134±£12,461 vs £9,276±£9,158), registrovane su statistički značajne razlike. Sve registrovane vrednosti bile su više u subuzorku igrača koji su pored ostalih povreda imali i povredu skočnog zgloba. U multivarijatnoj eksploraciji strukture osnovnih varijabli istraživanja dobijeni rezultati ukazuju na latentni prostor koji je imao interpretabilnu trodimenzionalnu struktru. Struktura prostora je ukazala na funkcionalno nezavisan odnos između učestalosti i intenziteta povređivanja, s jedne strane i hronološkog uzrasta, vrednosti transfera i igračke efiksanosti s druge. Zaključeno je da sportske povrede, a naročito povrede skočnog zgloba kod vrhunskih fudbalera imaju značajne ekonomske reprekusije.

Ključne reči: *sportske povrede, uganuće skočnog zgloba, ekonomske posledice povređivanja*

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Research article

WINTER SPORTS ACTIVITIES COURSE FOR FUTURE KINESIOLOGISTS: TRENDS AND CHALLENGES

UDC 796.01

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Abstract. *The purpose of this paper is to present a model of winter sports activities course organized for bachelor students of kinesiology during 2010 through 2017 with the aim of acquiring two main competencies: (i) methods for and approaches to promoting an effective use of leisure time for individuals and groups through outdoor activities in winter time, and (ii) understanding the content, purpose and process of outdoor winter sports activities. A total of 70 kinesiology students (26 men and 43 women, age 21.5±2.3 years) collaborated in the survey (26.5% response rate, N=264). Students classified their initial level of skiing knowledge as: 16% beginners, 39% average skiers, 23% good skiers and 22% very good skiers. Students detected significant progress in their skiing knowledge (11% excellent progress, 63% good/substantial progress and 26% only slight progress). However, students did not differ in their progress according to their initial ski knowledge ($\chi 2(9)=7.466$, $p<0.05$). 21% of the students achieved the Ski Instructor qualification at the end of program. Ski progress plays an important role in the evaluation of satisfaction with the professional knowledge applicable to future work as a kinesiologist ($\chi^2(2)=7.245$; $p=0.027$) and the course performance from the view of acquired knowledge usefulness applicable to future work as a kinesiologist ($\chi^2(2)=10.289$; $p=0.006$). Results open up new possibilities for further improvements of the winter camp and its activities. Because of the sports field legislation change in 2017, new organizational adjustments are expected.*

Key words: *Alpine Skiing, Education, Organization, Sport, Competencies*

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INTRODUCTION

Slovenia is a country with a long, well documented tradition of skiing, the national sport (Lešnik & Žvan, 2010). Winter sports hold third place among the most popular sports providers in Italy, Germany, Austria, the Czech Republic and Hungary, where sports tourism is one of the largest tourism providers (Vanat, 2015). Winter sports are the main sports tourism provider in Slovenia and Slovakia (Tourism Statistics-Winter Season Occupancy, 2019; Turizem, 2019). Recreational alpine skiing is becoming safer due to the use of protective gear, the introduction of short carving skis, more rigid and comfortable ski boots and better preparations of ski slopes (Johnson, Ettlinger, & Shealy, 2008; Coury et al., 2013). Alpine skiing allows individuals to tailor their recreational skiing to their personal health and physical fitness in order to achieve an optimal skiing intensity while also providing an enjoyable experience (Loland, 2006). Recreational alpine skiing is not only limited to the young, physically fit and healthy population, but often includes less fit individuals and a growing number of middle-aged and elderly skiers (Loland, 1992; Pišot, Paravlić, & Pišot, 2017). In Slovenia, the Ski instruction profession is regulated at the national level (Sports Act, 2017), as it is in the Czech Republic, France, Hungary, Portugal and Slovakia. In Germany - Bavaria, Spain, Italy, and Austria, the ski instructor profession is regulated at regional levels (European Commission, 2015) (Fig. 1).

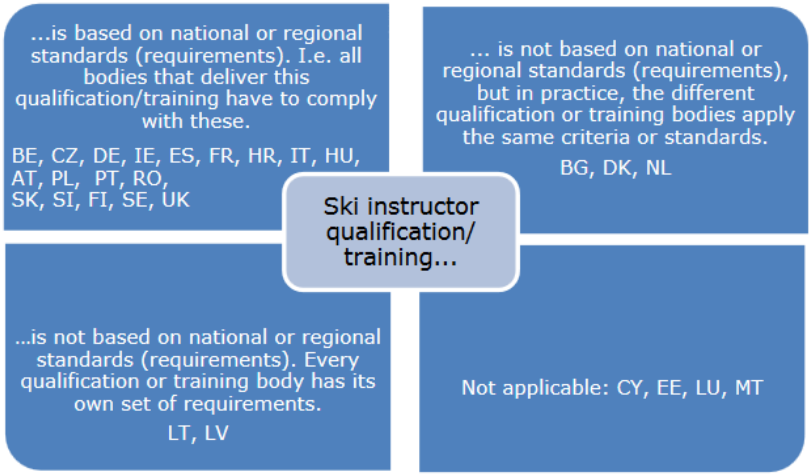


Fig. 1 Existence of standards for the alpine ski instructor qualification/training in European Union (European Commission, 2015)

In a significant majority of countries (in 18 of the EU-28 countries), certain (national or regional) standards, or similar requirements, are in place, with which providers of ski instructor qualifications or training need to comply.

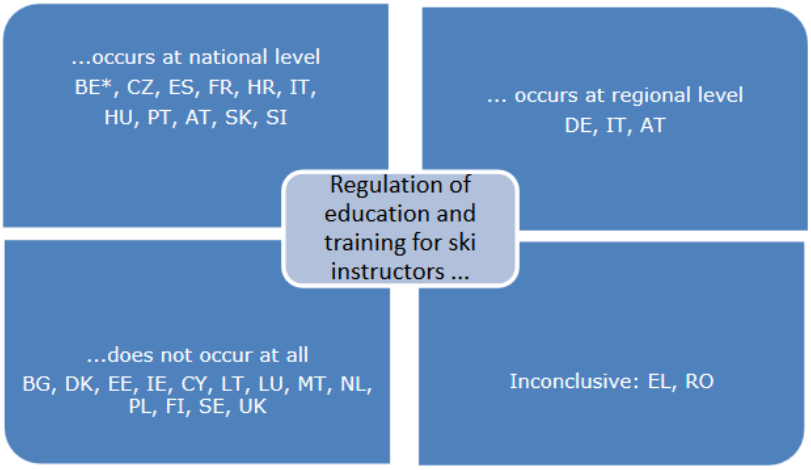


Fig. 2 Regulation of ski instructor education and training in European Union (European Commission, 2015)

Even in countries where neither the profession nor education and training of alpine ski instructors are regulated (Fig. 2), there might be an implicit requirement for ski instructors to possess a certain level of qualification or training. In June 2017, the Sports Act (The Official Gazette of the Republic of Slovenia 22/1998) in Slovenia changed after 19 years. The new Sports Act (The Official Gazette of the Republic of Slovenia 29/2017 and 21/2018) prescribes a 100% increase of content amount to satisfy the lowest criteria to achieve the Alpine Ski Instructor qualification as well as for other programs of professional training in sport areas in Slovenia. Sports Acts from 2017 and 2018 follow the directive on the recognition of professional qualifications and regulation in the European Union (European Parliament, 2013).

The Ski Association of Slovenia and its largest segment - Ski Instructors and Trainers Association of Slovenia (SIAS) - is the professional association representing one of the bases of the development of skiing in Slovenia. Its main goal is to educate high-quality ski instructors and trainers and cooperate intensively with all ski racing disciplines. With more than 80 years of tradition, SIAS has become one of the largest and most successful sports associations in Slovenia. SIAS consists of over 3400 members: about 83 % represent alpine skiing, 8 % snowboarding, 4 % cross country skiing, 3 % ski jumping, 1 % freestyle and freeride skiing, 1 % telemark skiing. According to the level of their professional license they are actively involved in the field of recreational skiing as well as in the training of top level professional athletes (Lešnik, 2017).

The Slovenian national ski school is based on four levels: 1. getting used to skis and basic forms of gliding, 2. basic forms of skiing, 3. advanced forms of skiing, and 4. competitive forms of alpine skiing and derived forms (Lešnik & Žvan, 2010). The core of the school is represented by the basic and advanced forms of skiing that are the basis of the skiing skills of a wide circle of people. The progress in mastering skiing skills depends primarily on the motor abilities of an individual and his/her base of psychomotor information (Lešnik, 2017). It is indisputable that beginners will make progress more easily and faster with the

help of skiing elements that enable more time to carry out the required movements in gliding on skies. At the same time, the instructor´s knowledge and skills are certainly important, as is the fact that a ski school enables a fast and effective mastering of technique (Žvan, Lešnik, & Supej, 2012). Movement on the snow in all its forms is the basis of many winter sports, as well as an important part of leisure time activities (Pišot, Kipp, & Supej, 2015; Kipp, 2012). Winter activities have been part of the educational programs in kindergartens, primary and secondary schools and university programs for many years now.

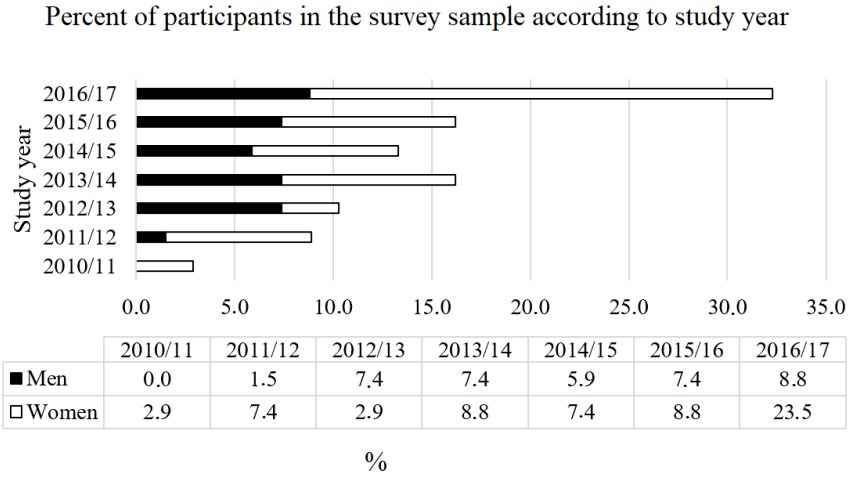
The teaching of skiing is determined by many factors, the ski school being one of the most important. It includes learning the elements of the skiing technique, from the basic forms of gliding and skiing to advanced, and possibly, even competitive forms of skiing (Lešnik & Žvan, 2010). To teach beginners ski movements, teachers try to find the best way of transferring knowledge (Cigrovski, Prlenda, & Radman, 2014). The ski school represents a hierarchy of ski elements. Their level of difficulty of the performance of movement on skies increases, as does the speed. Although various methods of teaching are used worldwide, the goal is the same – to teach as many people as possible to ski as well and as quickly as possible (Lešnik & Žvan, 2010; Pišot et al., 2015). Skiing is a sport requiring a wide range of motor skills and abilities. The skier must learn several different motor tasks through different phases of turns that were determined precisely in the past. Although the intention is to teach skiing skills in the most efficient way possible, we must be aware of the fact that the performance of ski elements at a certain level may be a very demanding task not only for a beginner, but also for a more experienced skier. The number of required motor actions of particular ski elements should be gradually increased, starting with the basic forms of skiing (Lešnik & Žvan, 2010; Pišot et al., 2015; Kipp, 2012; Puhalj & Lešnik, 2018). Alpine skiing is a sport with a significant risk of injury; however, strategies to prevent these include proper acquisition of techniques (Koehle, Lloyd-Smith, & Traunton, 2002).

In the framework of the bachelor study program Applied Kinesiology at the University of Primorska during 2010 through 2017, students were involved in a compulsory course called Winter Sport Activities in Nature, with the aim of acquiring two main competencies: (i) methods for and approaches to an effective use of leisure time for individuals and groups through outdoor activities in winter time, and (ii) understanding of the content, purpose, and process of sports activities in nature. The purpose of this paper is to present the evaluation of this course as derived from students' opinions.

METHODS

Sample of participants

70 students (26 men and 43 women, aged 21.5±2.3 years, Mean±Standard Deviation, i.e., M±SD) responded (26.5% response rate). Figure 3 presents the determination of participants according to the year in which they completed the course.



	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
■ Men	0.0	1.5	7.4	7.4	5.9	7.4	8.8
□ Women	2.9	7.4	2.9	8.8	7.4	8.8	23.5

Fig. 3 Percentage of participants according to the year of study in which they participated in the course

Students were classified by the initial level of skiing knowledge as: 16% beginners, 39% average skiers, 23% good skiers, and 22% very good skiers.

The procedure

An online questionnaire was composed in February 2017 and sent to all students of the applied kinesiology study program of the University of Primorska (N=264), who participated in winter activities as part of the study course Winter Sports Activities in Nature during the years 2010 through 2017. We were interested in the students' subjective assessment of: i) the individual progress in skiing knowledge during the Alpine skiing course, ii) the success in achieving the professional qualification of Ski Instructor, and iii) the overall satisfaction with the entire program of the winter course activities. Students evaluated their satisfaction with the course content on a Likert scale from 1 (not satisfied) to 5 (extremely satisfied).

Data analysis

The data were analysed with IBM SPSS Statistics 22.0, using a method of descriptive statistics and the analysis differences. Statistics assumptions were tested. We used $\chi 2$ and the Kruskal-Wallis test for analysis of differences among groups and Dunn's pairwise tests with the Bonferroni correction for post hoc analysis. The statistics significance was set at $p<0.05$. Data are presented as M±SD or as mean rank.

RESULTS

In the first year of the study program, a 6-day winter camp was organized in Forni di Sopra (Italy), which along with its infrastructure provides ideal conditions for effective implementation of the course in the extent of 1.5 ECTS (Plevnik, Gerževič, Pišot, Šturm, Baruca, & Pišot, 2017). According to the Slovenian Quality Assurance Agency for Higher Education (NAKVIS) 1 ECTS presents 30 hours of students' work (including contact work with the professor and his/her independent work) (Slovenian Quality Assurance Agency for Higher Education, 2019). The content of the course was divided into three parts: (i) the Alpine skiing course for all-level skiing knowledge (better skiers have the opportunity to achieve a professional qualification as a Ski Instructor); (ii) introduction to cross-country skiing and snowboarding, and (iii) additional (winter) activities and sports such as ice hockey, ice skating, sledding, night skiing, activities in the gym, swimming, and social activities (Table 1). The Alpine Ski course followed the Slovenian Alpine Skiing School program.

Table 1 Winter activities program for students 2010-2017 (hours of activities per student), performed during six successive days

Winter activity	Hours per student
Alpine skiing	30
Cross country skiing	3
Snowboarding	3
Outdoor winter activities (ice skating and hockey, sledding, night skiing with torches)	4
Theoretical lectures, video-analysis of the alpine skiing technique	5
Total	45

Students noted significant progress in their skiing knowledge (11% excellent progress, 63% good/substantial progress and 26% only slight progress). However, students did not differ in terms of statistical significance in their progress according to their initial ski knowledge ($\chi^2(9)=7.466$, $p<0.05$). 21% of the students were completing or had acquired the Ski Instructor qualification by the end of the program.

We evaluated the students' satisfaction with the substantive realization of the parts of the program (Tables 2 and 3) and satisfaction with the course content applicable to future work as kinesiologists (Table 4).

Table 2 Satisfaction with course content realization

Satisfaction with the substantive realization	Overall (M±SD)
of the overall program	4.4±0.7
of the alpine skiing program	4.3±0.8
of the cross county and snowboarding program	4.3±0.8
of the other outdoor winter activities	4.4±0.7
of the lectures / the theoretical part	3.8±0.7

Table 3 Satisfaction with course organization

Satisfaction with	Overall (M±SD)
difficulty of course content	4.0±0.6
professionalism of the teachers and professors	4.4±0.8
the location (Forni di sopra, Italy)	4.4±0.7
the infrastructure of the area	4.3±0.6

Satisfaction with course content realization and course organization did not differ based on the groups of initial ski knowledge, nor by the groups of ski progress.

Table 4 Satisfaction with the course content applicable to future work as kinesiologists

Satisfaction with	Overall (M±SD)	Slight progress group (Mean rank)	Substantial progress group (Mean rank)	Excellent progress group (Mean rank)	p
professional knowledge applicable to future work as a kinesiologist	3.9 ± 0.8	20.5	32.73	34.0	$\chi^2(2)=7.245$; p=0.027
organizational knowledge applicable to future work as a kinesiologist	3.9 ± 0.8				n.s.
course performance from the view of usefulness of acquired knowledge applicable to future work as a kinesiologist	4.0 ± 0.7	19.11	33.05	38.31	$\chi^2(2)=10.289$; p=0.006

DISCUSSION

Progress in ski knowledge (comparison among groups of slight, substantial and excellent ski knowledge progress) plays an important role in the evaluation of satisfaction with the professional knowledge applicable to future work as a kinesiologist ($\chi^2(2)=7.245$; p=0.027), as well as with the course performance from the view of acquired knowledge usefulness applicable to future work as a kinesiologist ($\chi^2(2)=10.289$; p=0.006). The results of the study indicate that progress in ski knowledge represents a crucial factor in evaluating course content for future work as a kinesiologist. A Kruskal-Wallis test provided very strong evidence of a difference (p<0.006) between the mean ranks of groups for satisfaction with the course performance from the view of content usefulness applicable to future work as a kinesiologist. Dunn's pairwise tests were carried out for the three pairs of groups. There was very strong evidence (p=0.028, adjusted using the Bonferroni correction) of a difference between the groups Slight progress - Substantial progress and (p=0.036, adjusted using the Bonferroni correction) of a difference between the groups Slight progress - Excellent progress. There was no evidence of a difference between the other pairs. It was estimated that the acquired knowledge for further work as kinesiologists is poor for 3%, good for 17%, very good for 55% and excellent for 25% of the students.

Short questionnaires, such as one used in our study, are easily accessible practical instruments for investigation. Alpine ski instructors play a powerful role in influencing skiing beginners both positively and negatively. Instructor's accountability for teaching, as well as for motivation and positive attitude development, impact skiing beginners' activity choices based on their attitudes (Luke & Sinclair, 1991).

Identification of factors associated with students' choice to either use the outdoor winter exercise/sport activities as future kinesiologists or not could provide useful information to teachers who wish to enhance the appeal of their curricular content and instructional practices. Skiing and other winter sports are an enjoyable, exciting activity performed in a stunning outdoor environment (Pišot & Videmšek, 2004; Kipp, 2012; Loland, 2020). Cigrovski, Radman, Matković, Gurmmet, & Podnar (2014) note that the alpine ski course program positively affects an attitude change in favor of alpine skiing and winter activities for participants. Additionally, they conclude that a structured program of skiing can improve the attitude towards alpine skiing.

When ski instructors are familiar with the attitudes and expectations of their skiing beginners in advance, they can adjust the program content to increase interest in skiing and winter activities. Moreover, the ski course program, as a means of structured learning, might positively influence attitudes towards skiing and winter activities and lead to further popularization of sport and physical activity. Changes in national legislation are leading to new organizational as well as substantive adaptations of winter sports programs for future kinesiologists.

CONCLUSION

The purpose of this study was to evaluate the winter sports activities course from the view of future kinesiologists. Evaluation of the implemented activities provides us insight into the students' (users') opinion regarding the quality of the activities undertaken during the winter camp, the quality of the organization and the level of the competencies achieved by the students. Students' feedback opens up new possibilities for further improvements of the winter camp and its activities, maintaining the achieved level of quality of the program and acquainting the students with the latest trends.

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KURS ZIMSKIH SPORTSKIH AKTIVNOSTI ZA BUDUĆE KINEZIOLOGE: TRENDOVI I IZAZOVI

Svrha ovog rada je da predstavi model kursa zimskih sportskih aktivnosti koji je organizovan za diplomirane studente kineziologije tokom perioda od 2010. do 2017. godine sa ciljem dobijanja dve glavne kompetencije: (i) metode i pristupi za unapređenje efikasne upotrebe slobodnog vremena za pojedince i grupe kroz aktivnosti na otvorenom u zimskom periodu i (ii) razumevanje sadržaja, svrhe i procesa zimskih sportskih aktivnosti na otvorenom. U istraživanju je učestvovalo ukupno 70 studenata kineziologije (26 muškaraca i 43 žene, starosti od 21.5±2.3 godine) (stopa odziva 26.5%, N=264). Studenti su inicijalno skijaško znanje klasifikovali kao: 16% početnici, 39% prosečni skijaši, 23% dobri skijaši i 22% vrlo dobri skijaši. Studenti su otkrili značajan napredak u svom skijaškom znanju (11% izvrstan napredak, 63% dobar/značajan napredak i 26% samo neznatan napredak). Međutim, studenti se nisu razlikovali u napretku u odnosu na svoje početno skijaško znanje ($\chi 2$ (9)=7.466, $p<0,05$). 21% studenata je steklo kvalifikaciju instruktora skijanja na kraju programa. Skijaški napredak igra važnu ulogu u proceni zadovoljstva profesionalnim znanjem koje se može primeniti za budući rad kineziologa ($\chi 2$ (2)=7.245; $p=0.027$) i performansama kursa sa aspekta korisnosti stečenog znanja koje se može primeniti na budući rad kineziologa ($\chi 2$ (2)=10.289; $p=0.006$). Rezultati otvaraju nove mogućnosti za dalja poboljšanja zimskog kampa i njegovih aktivnosti. Zbog promene zakona u području sporta u 2017. godini očekuju se nova organizacijska prilagođavanja.

Ključne reči: *alpsko skijanje, edukacija, organizavija, sport, competicije*

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Research article

TREND CHANGE IN THE MORPHOLOGICAL FEATURES OF BOYS AGED SEVEN TO TEN

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Abstract. *The aim of this research was to determine the trend change in the morphological features of boys aged 7 to 10, of various nutritional status, with particular emphasis on the trend of occurrence of obesity among the same population. The sample consisted of 1164 boys, divided into four sub-groups (based on their age), and then each sub-group was further divided into three groups depending on their nutritional status. Four morphological factors were measured: the longitudinal, transversal and circular dimensionality of the skeleton, body mass and subcutaneous fat tissue. They were used to determine the morphological characteristics of the participants. The data were processed using the SPSS 20.0 statistics program. To determine the dynamics of change in the increasing or decreasing continuum, a trend analysis was used. By analyzing and evaluating the results obtained during the course of this study, differences in morphological characteristics were determined between children with normal body mass, overweight children and obese children of various ages. The dynamic of the change in the aforementioned characteristics in most morphological spaces of the boys indicated a continued increase that accompanies the age of the participants. Among the participants with normal body mass and overweight participants, a discontinued form of development among the morphological characteristics was noted. The discontinued form of development is visible among obese participants in the space which refers to measuring subcutaneous fat tissue. A significantly greater annual increase in body fat, compared to the average, was also noted.*

Key words: *Body Build, Young School Age Children, Obesity, Growth, Development*

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INTRODUCTION

The morphological characteristics of human anthropological status usually include growth processes and human ontogenetic development. Morphological space is in essence four-dimensional: the longitudinal dimensionality of the skeleton; transversal dimensionality of the skeleton; body volume and mass; and subcutaneous fat tissue (Malacko & Rađo, 2004; Živković, 2019).

The existing literature indicates that morphological characteristics, viewed as a factor of anthropological status, represent the biological and physiological basis through which anthropometric measurements are manifested (Popović & Radanović, 2010; Đošić et al., 2019).

Humans go through several phases of growth and development including the following: The first phase of rapid growth lasts from birth to the age of three. The next phase is one of deaccelerated growth and consists of two cycles of development: the preschool age (from the age of four to seven) and the younger school age (from the age of seven to eleven). The prepubescent and pubescent phase are known for their intense growth and development, otherwise known as the middle school age (from the age of 11 to 15 of one's extrauterine life). Older school age is a phase of development where sexual maturation takes place, which lasts up until the age of 20, and belongs to the second cycle of deaccelerated growth. The growth process and ossification end at the age of 25 (Đurašković, 2009).

Information which is of significant relevance for the aforementioned factors can be obtained from morphological characteristics, that is, the anthropometric measurements of children (Madić, Popović, & Kaličanin, 2009). The aforementioned method is used to establish the nutritional status of children and adolescents, which represents one of the most important indicators of health, psychophysical abilities and the potential for normal growth and development (Stamenkovič, Bratić, Berić, & Pantelić, 2017). Thus, it can function as a prognostic factor of their state of health (Marković, Igrutinović, Kostić, & Vuletić, 2008; Pavlica, Rakić, & Sironjić, 2017). Any greater deviations from optimal body mass values are indicators of symptoms of a health disorder, or indicators of a preexisting condition (Vlaški & Katanić, 2010).

Physical inactivity and the increase in energy intake lead to changes in the morphological status of children and young people. According to the World Health Organization, in 2016 there were 41 million obese children in the world under the age of 5, and over 340 million obese children and adolescents aged between 5 and 19. The prevalence of overweight and obesity increased from 4% in 1975 to over 18% in 2016 (WHO, 2017 according to Živković, 2019). According to Spruijt-Metz (2011) several factors can be singled out as a consequence of the increase in obesity: Genetic (Robiou-du-Pont et al., 2017); biological and psychological (Tripicchio et al., 2017); socio-cultural (Hasson et al., 2005); and environmental factors (Rath et al., 2016). Various studies have shown that the rate of obesity in industrialized countries is on the rise, as it is in developing countries (Apovian & Riffenburg, 2017; Ghanemi & St-Amand, 2018).

Although Serbia is not at the top of the list of countries with a sharp rise in obesity, among children and adolescents obesity has taken on epidemic proportions (Wang & Lobstein, 2006). The official documents of the Ministry of Health of the Republic of Serbia confirm that one-fifth of children and the young aged 7 to 19 (18%) is overweight and obese (the Ministry of Health of the Republic of Serbia, 2007 according to Đošić et al., 2019).

The aim of this research was to determine the trend change in the morphological features of boys aged 7 to 10, of various nutritional status, with particular emphasis on the trend of occurrence of obesity among the same population.

METHODS

The sample of participants included younger school aged boys, aged 7 to 10. The overall sample consisted of 1164 boys, divided into four subsamples in relation to their age (SS1, SS2, SS3, and SS4). Each subsample in turn was divided into three groups, depending on their nutritional status (participants with normal body mass, participants who are overweight, and obese participants). SS1 included 254 children aged 7 of whom 168 had a normal nutritional status (66%), 47 were overweight (19%) and 39 were obese (15%). SS2 included 288 children aged 8 of whom 196 had a normal nutritional status (68%), 49 were overweight (17%) and 43 were obese (15%). SS3 included 278 children aged 9 of whom 166 had a normal nutritional status (60%), 70 were overweight (25%) and 42 were obese (15%). SS4 included 344 children aged 10 of whom 199 had a normal nutritional status (58%), 93 were overweight (27%) and 52 were obese (15%).

The results were obtained using the body mass index (BMI, in kg/m^2), which was adapted to the age of the children, and in accordance with the tables provided by the Cole, Bellizzi, Flegal, & Dietz (2000).

For the participants included in the study, approval was obtained from the school principal, the teachers and parents. At the same time they were acquainted with the rules and means of the measurement.

Measuring instruments for the evaluation of morphological characteristics

By measuring four morphological factors (longitudinal dimensionality of the skeleton, transversal dimensionality of the skeleton, circular dimensionality and body mass, subcutaneous fat tissue) the morphological characteristics of the participants were determined: 1) The longitudinal dimensionality of the skeleton (*Body height in cm; Leg length in cm*; *Arm length in cm)*; 2) The transversal dimensionality of the skeleton (*Shoulder width in cm; Pelvic width in cm; Hip width in cm)*; 3) Body mass and circular dimensionality (*Body mass in kg; Average thoracic volume in cm; Volume of the extended upper arm in cm; Thigh volume in cm)*; 4) Subcutaneous fat tissue (*Upper arm skinfolds in mm; Back skinfolds in mm; Abdominal skinfolds in mm).*

The measurements were carried out following the standard procedures based outlined in the International Biological Program (Weiner & Lourie, 1969).

Data processing was carried out using the statistical program SPSS 20.0. To determine the dynamics of change along the increasing or decreasing continuum, a trend analysis was used.

RESULTS AND DISCUSSION

In 7 years old boys and in relation to BMI values are given as follows: normal-15.59; overweight-19.19; obese-23.16. In 8 years old boys those were: normal-16.00; overweight-19.70; obese-24.35. In 9 years old boys those were: normal-16.27; overweight-20.75; obese-24.41. In 10 years old boys those were: normal-17.02; overweight-21.80; obese-26.35.

An overview of morphological features of boys aged 7 to 10 of various nutritional status is presented in Table 1.

Table 1 Mean values of morphological features of boys aged 7 to 10 of various nutritional status

Anthropometric measures	Mean			
	7 years old	8 years old	9 years old	10 years old
BMI (kg/m^2)	normal-15.59 overweight-19.19 obese-23.16	normal-16.00 overweight-19.70 obese-24.35	normal-16.27 overweight-20.75 obese-24.41	normal-17.02 overweight-21.80 obese-26.35
Body height (cm)	normal-127.54 overweight-130.92 obese-132.71	normal-134.16 overweight-137.66 obese-138.48	normal-139.45 overweight-143.21 obese-145.28	normal-145.22 overweight-147.85 obese-150.63
Leg length (cm)	normal-69.48 overweight-71.97 obese-72.22	normal-74.28 overweight-77.67 obese-76.70	normal-77.85 overweight-80.95 obese-81.01	normal-82.01 overweight-83.38 obese-85.31
Arm length (cm)	normal-54.10 overweight-55.17 obese-55.75	normal-56.64 overweight-58.73 obese-58.47	normal-58.94 overweight-61.33 obese-61.60	normal-62.12 overweight-63.16 obese-64.89
Shoulder width (cm)	normal-28.58 overweight-29.99 obese-30.58	normal-29.84 overweight-31.47 obese-32.55	normal-30.71 overweight-32.37 obese-33.61	normal-32.10 overweight-33.98 obese-35.40
Pelvic width (cm)	normal-20.23 overweight-21.77 obese-22.77	normal-21.21 overweight-22.90 obese-24.57	normal-21.62 overweight-23.52 obese-25.44	normal-22.79 overweight-24.73 obese-27.07
Hip width (cm)	normal-21.36 overweight-23.33 obese-24.62	normal-22.51 overweight-24.63 obese-26.26	normal-23.20 overweight-25.41 obese-27.14	normal-24.75 overweight-26.85 obese-29.04
Body mass (kg)	normal-25.42 overweight-32.99 obese-40.99	normal-28.89 overweight-37.43 obese-46.79	normal-31.71 overweight-42.73 obese-51.64	normal-36.03 overweight-47.79 obese-60.04
Thoracic volume (cm)	normal-58.89 overweight-64.83 obese-71.23	normal-60.99 overweight-68.28 obese-74.91	normal-63.59 overweight-70.93 obese-78.22	normal-66.39 overweight-74.95 obese-81.88
Upper arm volume (cm)	normal-17.09 overweight-20.36 obese-23.00	normal-17.88 overweight-21.22 obese-24.18	normal-18.58 overweight-22.34 obese-24.82	normal-19.71 overweight-23.67 obese-26.70
Thigh volume (cm)	normal-33.97 overweight-39.43 obese-44.75	normal-35.80 overweight-41.47 obese-45.74	normal-37.46 overweight-44.68 obese-48.65	normal-40.11 overweight-45.79 obese-50.14
Upper arm skinfold (mm)	normal-9.32 overweight-14.95 obese-20.31	normal-10.05 overweight-15.44 obese-19.95	normal-10.25 overweight-16.97 obese-23.03	normal-11.11 overweight-18.18 obese-24.51
Back skinfold (mm)	normal-5.93 overweight-10.60 obese-18.67	normal-6.25 overweight-10.75 obese-18.81	normal-6.48 overweight-13.63 obese-21.16	normal-7.02 overweight-13.99 obese-20.39
Abdominal skinfold (mm)	normal-6.23 overweight-14.32 obese-21.89	normal-7.20 overweight-15.93 obese-24.30	normal-7.55 overweight-19.09 obese-26.10	normal-8.94 overweight-20.33 obese-26.45

Table 2 Trend analysis of the morphological characteristics of participants with normal nutritional status

	F	Sig
Body height (cm)	236.39	.000**
Leg length (cm)	243.03	.000**
Arm length (cm)	242.72	.000**
Shoulder width (cm)	156.59	.000**
Pelvic width (cm)	118.62	.000**
Hip width (cm)	181.26	.000**
Body mass (kg)	216.85	.000**
Thoracic volume (cm)	130.23	.000**
Upper arm volume (cm)	83.77	.000**
Thigh volume (cm)	91.01	.000**
Upper arm skinfold (mm)	10.22	.000**
Back skinfold (mm)	7.11	.000**
Abdominal skinfold (mm)	14.69	.000**

Legend: *F* – Rao's F approximation; *sig* – level of significance

Table 2 shows the results of the trend analysis of the morphological characteristics of individuals with normal nutritional status, aged seven, eight, nine and ten. A statistically significant trend was determined for all the measured variables at the .01 level of statistical significance.

Table 3 Trend analysis of the morphological characteristics of overweight participants

	F	Sig
Body height (cm)	66.69	.000**
Leg length (cm)	57.76	.000**
Arm length (cm)	67.90	.000**
Shoulder width (cm)	63.95	.000**
Pelvic width (cm)	48.12	.000**
Hip width (cm)	68.22	.000**
Body mass (kg)	106.37	.000**
Thoracic volume (cm)	65.57	.000**
Upper arm volume (cm)	60.25	.000**
Thigh volume (cm)	43.43	.000**
Upper arm skinfold (mm)	8.71	.000**
Back skinfold (mm)	9.83	.000**
Abdominal skinfold (mm)	14.39	.000**

Legend: *F* – Rao's F approximation; *sig* – level of significance

Based on the results presented in Table 3, which shows the trend analysis of the morphological characteristics of overweight participants aged seven, eight, nine and ten, it can be concluded that there is a statistically significant trend for the applied measures at the .01 level of statistical significance.

Table 4 Trend analysis of the morphological characteristics of obese participants

	F	Sig
Body height (cm)	82.18	.000**
Leg length (cm)	81.77	.000**
Arm length (cm)	82.96	.000**
Shoulder width (cm)	47.19	.000**
Pelvic width (cm)	52.53	.000**
Hip width (cm)	66.40	.000**
Body mass (kg)	66.02	.000**
Thoracic volume (cm)	30.29	.000**
Upper arm volume (cm)	20.36	.000**
Thigh volume (cm)	14.04	.000**
Upper arm skinfold (mm)	4.57	.004**
Back skinfold (mm)	1.44	.234
Abdominal skinfold (mm)	3.32	.021*

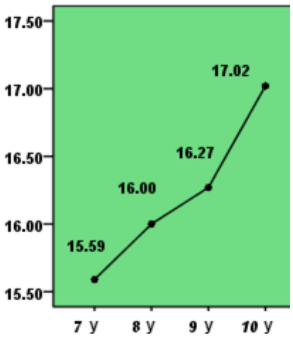
Legend: F – Rao's F approximation; *sig* – level of significance

Table 4 shows the results of the trend analysis of the morphological features of obese participants aged seven, eight, nine and ten. A statistically significant trend in the variables of longitudinal, transversal and circular dimensionality, along with body mass, were determined and at the .01 level of statistical significance. When it comes to subcutaneous fat tissue, a statistically significant trend was noted for upper arm and abdomen skinfolds, while none was recorded for the back skinfolds.

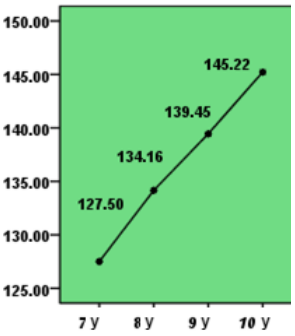
The dynamics of change in the morphological characteristics of participants with various nutritional status is shown in Graphs 1, 2, and 3.

The growth and development of children is to the greatest extent genetically conditioned, where the aforementioned determinance mostly refers to the space of longitudinal dimensionality of the skeleton (Malina, Boushard. & Bar-or, 2004; Stupar, 2016). Previous research has indicated that a continued form of linear growth was noted during the first ten years of life (Rogol, Roemmich, & Clark, 2002; Wells, 2007). At that time, the differences between boys and girls in terms of most anthropometric measurements are more or less insignificant, until they enter puberty when sudden changes and differences occur (Malina & Bouchard, 1991). However, a trend of increase was noted for the parameters which indicate overweight and obesity among children, compared to past measurements. In this research we can see from the results that over the years, the percentage of overweight and obese participants has increased, among participants aged 7 - 34%, aged 8 - 32%, aged 9 - 40% and aged 10 - 42%, from the ages of 7 to 10 the percentage of obesity did not change and had a value of 15%, while excessive overweight increased over time. Compared to previous research (Đokić & Stojanović, 2010; Ostojić, Stojanović, Stojanović, Marić, & Njaradi, 2011) in which the percentage of obesity among boys of a younger school age ranged from 4.6% - 8.2%, data of 15% - obese indicate a significant increase in the obesity of boys of the same age category.

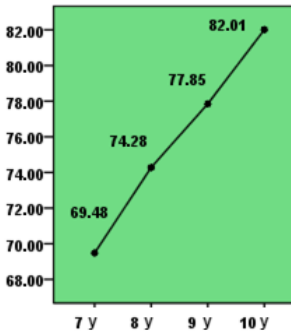
The dynamics of change in the morphological characteristics of participants with normal nutritional status are shown in Graph 1, while the results shown in Table 3 have indicated a statistically significant trend for all measurements used to evaluate the morphological characteristics of the participants with normal body mass, at the .01 level of statistical significance.



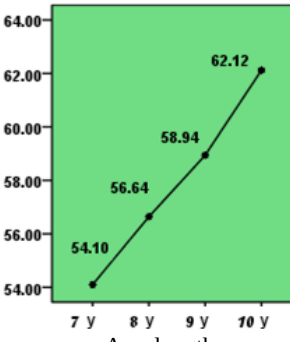
Body Mass Index-BMI



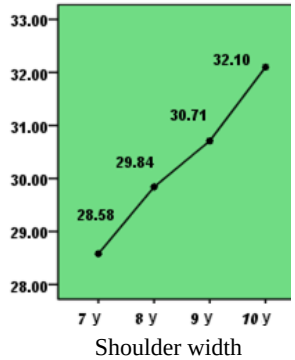
Body height



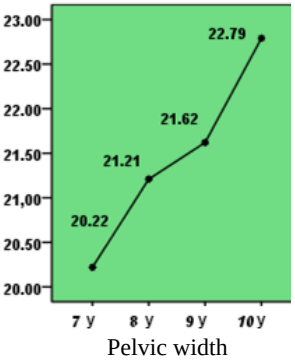
Leg length



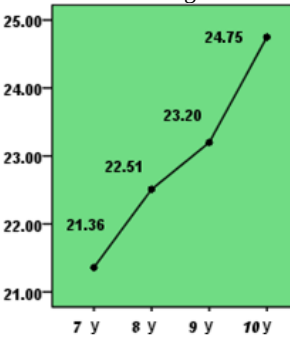
Arm length



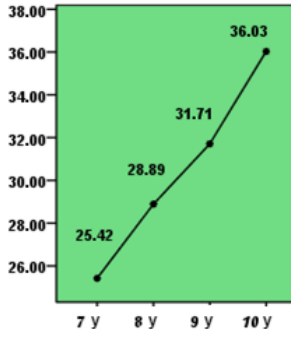
Shoulder width



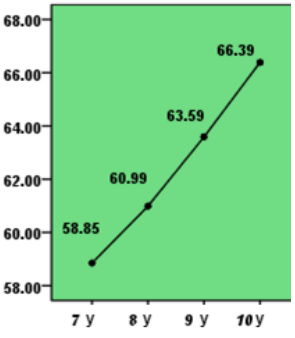
Pelvic width



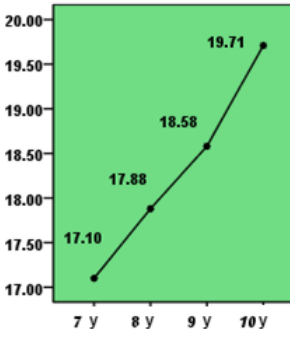
Hip width



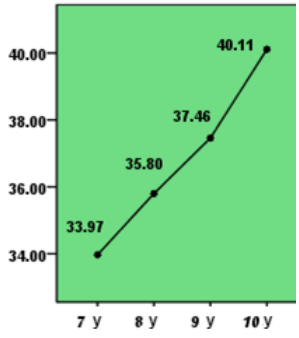
Body mass



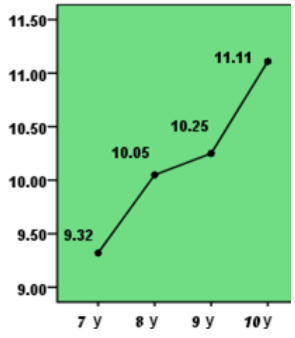
Thoracic volume



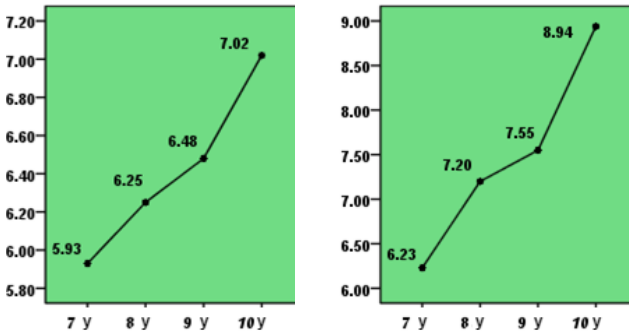
Upper arm volume



Thigh volume



Upper arm skinfolds



Back skinfolds Abdominal skinfolds

Graph 1 The dynamics of change in the morphological characteristics of participants with normal nutritional status, ages seven to ten

For the body mass index, a continued increase in the results in accordance with the increase in the age of the participants is noticeable, while the greatest increase was noted for children aged nine to ten. The obtained results are in agreement with the research results of Schaefer, Georgi, Wühl, & Schärer (1998) where it was confirmed that the BMI and percentage of fat tissue increased during growth, so that the value was greater with the increase in the age of the participants.

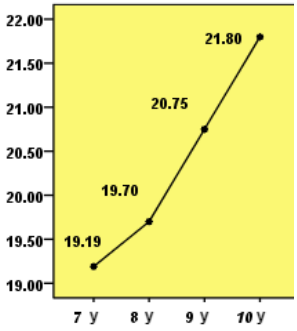
A relatively equal continued form of growth which accompanies the increase in the age of the participants can be seen in all three variables of the longitudinal dimensionality of the skeleton (body height, arm length and leg length).

In the space of transversal dimensionality of the skeleton (shoulder width, pelvic width and hip width), based on the linear graph, we can note a continued increase in the results which accompanies the increase in the age of the participants, where the greatest increase was noted between the ages of nine and ten. These results are compatible with previous research (Popović, 2008; Đorđević, 2015).

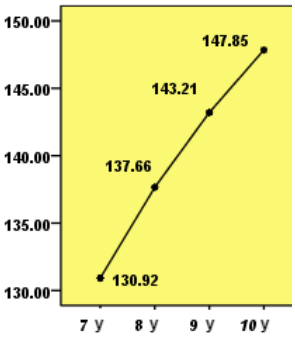
Without any significant oscillations, the dynamics of change in body volume and mass (body mass, thoracic volume, upper arm volume, and thigh volume) have indicated a continued growth from the ages of seven to ten, which is analogous with the study of Popović (2008).

The graphs which indicate the dynamics of change of subcutaneous fat tissue (upper arm skinfold, abdominal skinfold, and back skinfold) of participants with normal body mass showed a continued increase in the values which accompanied the increase in the age of participants aged seven, eight, nine and ten. Between the ages of eight and nine, in all three morphological measurements (upper arm skinfolds, abdominal skinfolds and back skinfolds), the smallest increase in the values was noted. The obtained results are in agreement of those of Schaefer et al. (1998). Still, in some studies a discontinued form of development in subcutaneous fat tissue was noted (Popović, 2008; Đorđević, Živković, Ranđelović, Pantelić, & Mitrović, 2017).

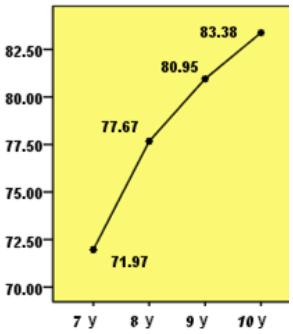
Based on the analysis of the results shown in Graph 1 (the dynamics of change in the morphological characteristics of individuals with normal nutritional status aged seven, eight, nine and ten), it could be concluded that in all the measurements for the evaluation of morphological characteristics, a continued form of growth with an increase in the age of the participants was noted. The obtained results were mostly in agreement with the results of previous studies (Popović, 2008; Runhaar et al., 2010; Đorđević, 2015).



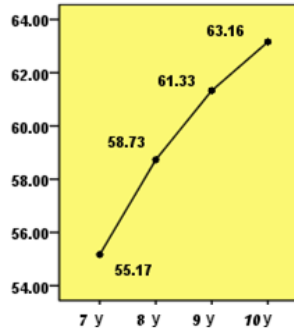
BMI



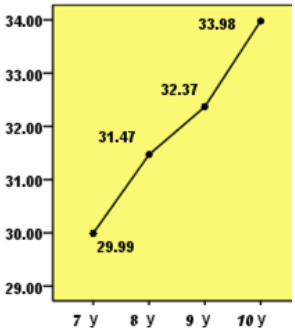
Body height



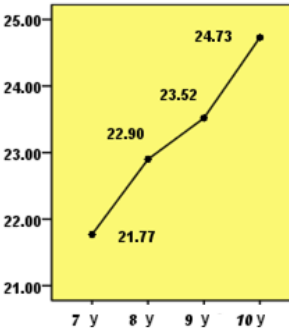
Leg length



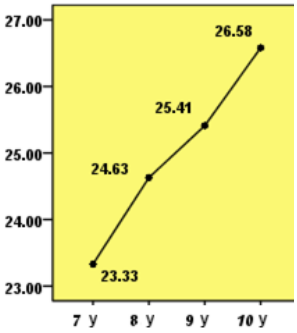
Arm length



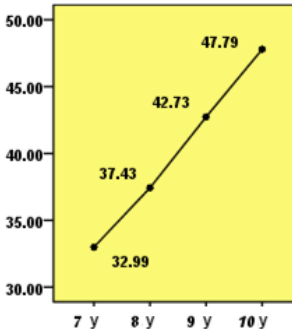
Shoulder width



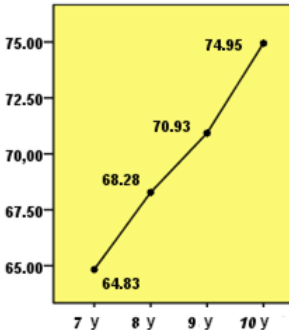
Pelvic width



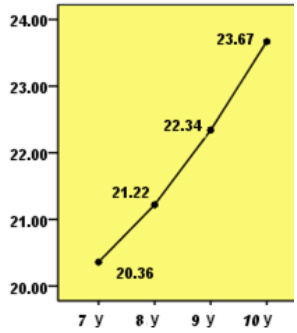
Hip width



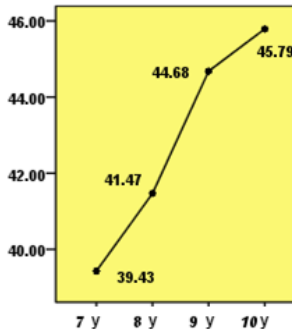
Body mass



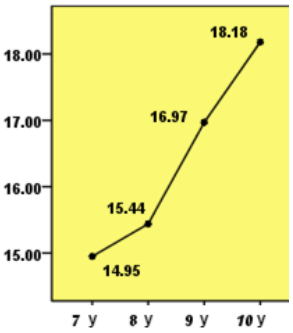
Thoracic volume



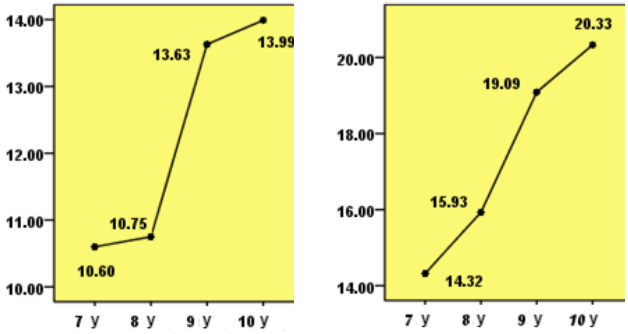
Upper arm volume



Thigh volume



Upper arm skinfolds



Back skinfolds Abdominal skinfolds

Graph 2 The dynamics of change of the morphological characteristics of overweight participants aged seven to ten

The dynamics of change in the morphological characteristics of overweight participants are shown in Graph 2. The existence of a statistically significant trend on the tests for the evaluation of all of the measured morphological characteristics was determined at the .01 level of statistical significance.

The dynamics of change in the BMI showed continued growth with an increase in age of the overweight participants. The smallest increase was noted for the ages of seven to eight, after which there was a period of more intense growth from the age of nine to ten. Similar results were obtained by the researchers Schaefer et al. (1998).

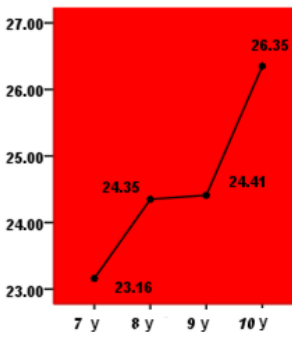
In the case of the measures for the evaluation of the longitudinal dimensionality of the skeleton (body height, leg length and arm length), a continued form of growth accompanying the increase in the age of the participants can be noted for all the variables of the aforementioned dimension (body height, leg length, and arm length). The greatest growth was noted from the ages of seven to eight, which is to a great extent in agreement with previous studies (Popović, 2008; Đorđević, 2015).

By analyzing the curve of the transversal dimensionality of the skeleton (shoulder width, pelvic width and hip width) we can see a trend of increase with the increase in the age of the participants. The smallest increase was noted for all three parameters of the aforementioned space from the ages of eight to nine, while the trend of increase between the ages of seven and eight, as well as nine and ten, is slightly more intense (Đorđević, 2015).

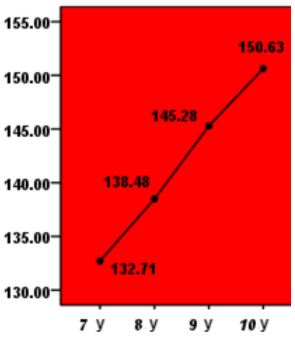
In the space of body mass and volume, a continued increase in all the measures for its evaluation (body mass, thoracic volume, upper arm volume and thigh volume) can be noted. Based on the results we can see that in the case of body mass, thoracic volume and upper arm volume it is approximately equal to the increase in the age of the participants, where in the case of thigh volume the greatest increase in value is between the ages of eight and nine, and the smallest from the age of nine to ten.

In the space of subcutaneous fat tissue, the curve of the upper arm skinfold shows the least increase from the age of seven to eight. After that the values are greater with the increase in the age of the participants, until the age of ten. For the back skinfolds we can note that the greatest increase is between the age of eight and nine among overweight participants. Similar dynamics can be seen for the abdominal skinfolds, which is similar to the results of previous studies (Popović, 2008).

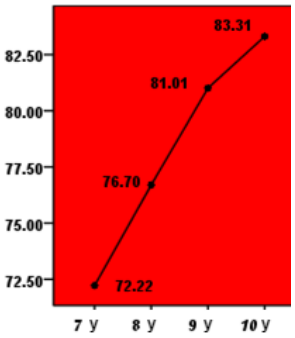
By analyzing the results in Graph 2, a continued form of increase was identified with an increase in the age of the participants for all the morphological measurements, which is in agreement with the study of Schaefer et al. (1998). They determined that the values of the body mass index and the percentage of fat tissue increased with the increase in the age of the participants.



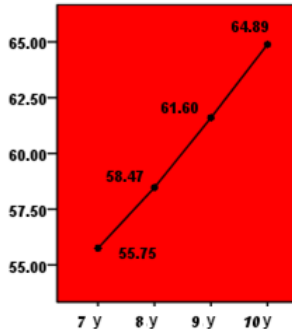
BMI



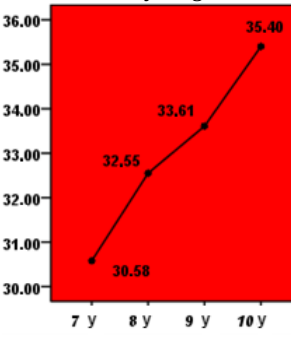
Body height



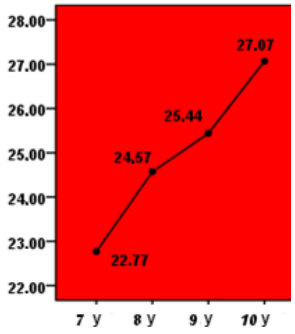
Leg length



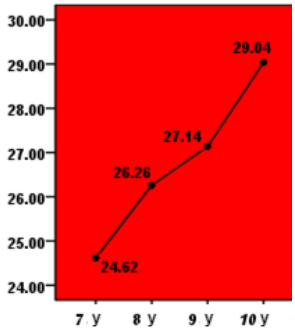
Arm length



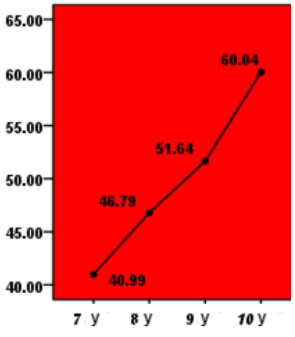
Shoulder width



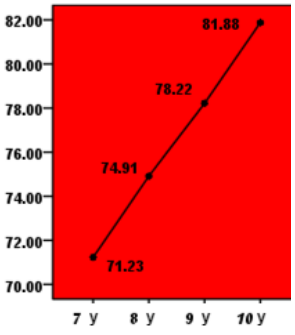
Pelvic width



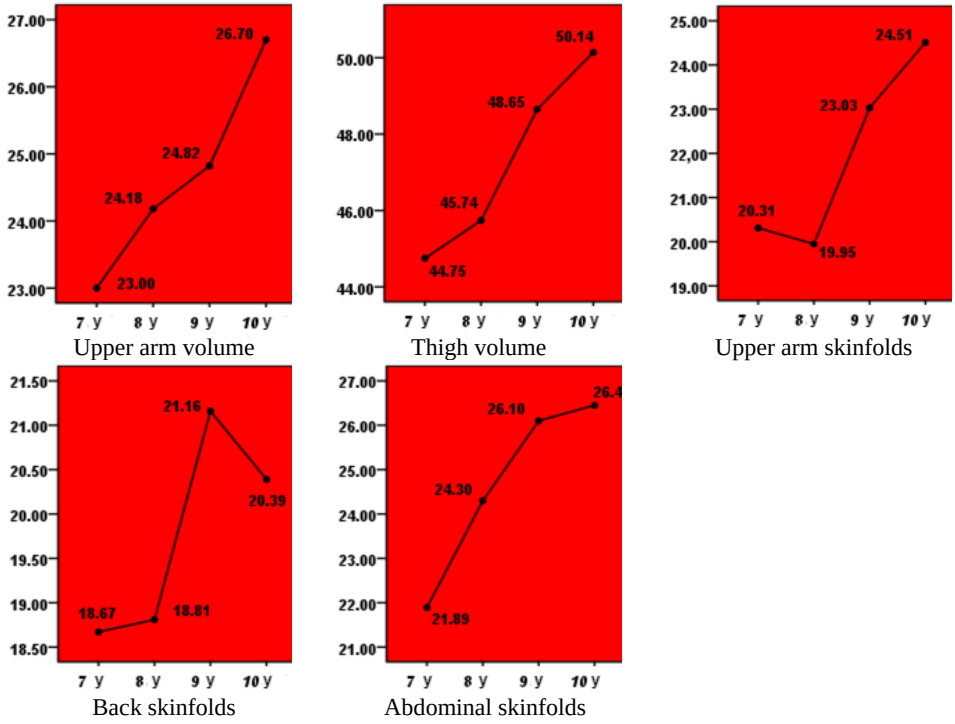
Hip width



Body mass



Thoracic volume



Graph 3 The dynamics of change in the morphological characteristics of obese participants aged seven to ten

Graph 3 indicates the trend of mean values of the morphological characteristics of the participants aged seven, eight, nine and ten, who based on their body mass index belong to the group of overweight participants. A statistically significant trend was determined for all the measures used to evaluate longitudinal dimensionality of the skeleton (body height, leg length and arm length), the transversal dimensionality of the skeleton (shoulder width, pelvic width and hip width), and body mass and volume (body mass, thoracic volume, upper arm volume and thigh volume) at the .01 level of statistical significance, while in the space of subcutaneous fat tissue a statistically significant intergroup difference was visible for the upper arm skinfolds and abdominal skinfolds.

The curve of the body mass index indicates a continued form of increase with an increase in the age of the participants, where the smallest changes can be noted between the ages of eight and nine, and then a sudden growth and the highest values at the age of ten. Similar results were obtained by Ogden, Flegal, Carroll, & Johnson (2002) who point out that the body mass index increased with the age of the participants.

In the space of the longitudinal dimensionality of the skeleton (body height, leg length and arm length), we can see a continued form of growth with the increase in the age of the participants. The greatest values recorded for the obese participants were noted at age ten, which is in agreement with the results of other researchers (Malina et al., 2004).

In the space of transversal dimensionality of the skeleton (shoulder width, pelvic width and hip width), by studying the curve of the aforementioned space we can see a

continued form of growth which accompanies the increase in the age of the obese participants, where from the ages of eight to nine the increase is the smallest. After that there is a more intense increase in all the measures of transversal dimensionality of the skeleton when the participants reach the age of ten.

The dynamics of the change in the measures for the evaluation of body volume and mass (body mass, thoracic volume, upper arm volume and thigh volume) have a continued form of growth from the age of seven to the age of ten. For upper arm volume we can note that the smallest increase occurs from the ages of eight to nine, and the greatest from the age of nine to the age of ten. For thigh volume the results indicate the smallest increase between the ages of seven and eight, and after that the greatest until the age of nine, while the greatest values were noted at the age of ten for the obese group of participants, in all the parameters for the evaluation of volume and body mass. These results are in part in accordance with the results of the study carried out by Đorđević (2015).

In the case of subcutaneous fat tissue, in two of the three variables (upper arm skinfold and back skinfold) a discontinued form of development was noted with the increase in the age of the participants. To be precise, for the upper arm skinfolds, there is a clear decrease in the values between the ages of seven and eight, followed by their continued growth until the age of ten, when the greatest values of the aforementioned measure were noted. The curve of the back skinfold indicates a slight increase in the results from the ages of seven to eight, which is followed by the greatest increase until the age of nine, which at the same time represents the greatest result for the aforementioned measure. After that there is a decrease in the value until the age of ten among the obese participants. The only variable in the space of subcutaneous fat tissue where the curve indicates continued growth with the increase in the age of the participants, and the greatest values at age ten, is abdominal skinfold. The obtained results are to the greatest part analogous to the results of the research of Popović (2008).

Generally speaking, the dynamics of change in the morphological dimensions of obese participants aged seven, eight, nine and ten for most of the morphological measures have indicated a continued form of growth with an increase in the age of the participants, while for two of the parameters from the space of subcutaneous fat tissue (upper arm skinfold and back skinfold) a discontinued form of development with the increase in the age of the participants was noted. The obtained results are for the most part compatible with the results of the study carried out by Popović (2008) where the author indicates a continued form of growth with the increase in the age of obese participants in terms of body height, mass and the measures for the evaluation of body voluminosity, while a discontinued form of development with the increase in the age of the participants was noted in the space of subcutaneous fat tissue among children of a younger school age. Similar results were noted in the study of Živković, Đorđević, Ranđelović, & Bjelaković (2018), where in the space of subcutaneous fat tissue, a discontinued form of development was determined.

The speed of growth and nutritional level of children after the age of three and all the way to the beginning of puberty is mostly similar, and has a value of 5-7.5 cm, while the increase in body mass has a value of 2-3 kg on an annual level (Zdravković, Banićević, & Petrović, 2009). After analyzing the set norms and standards for growth and development, we come to the conclusion that there are certain deviations among the obese participants. In the group of obese boys, an increase in body mass ranging from 5 to 10 kg a year can be noted. Similar results were found by Živković et al. (2018), who indicated an annual increase in body mass of 4 to 10kg.

By analyzing and evaluating the results obtained in this research, the differences in the morphological characteristics of children with normal nutritional status, and those of obese children of various ages were determined. The dynamics of change of the aforementioned characteristics in most of the morphological spaces of boys indicates a continued form of development with the increase in the age of the participants. Among normal and overweight participants, no discontinued form of development of morphological characteristics was noted. A discontinued form of development is visible among obese participants in a smaller number of variables, in particular in the space which refers to the measuring of subcutaneous fat tissue. Furthermore, a significantly greater increase in body mass on an annual level can be noted in comparison to the average can be noted. The percentages indicate a much greater number of obese children compared to previous studies with a similar focus (Živković et al., 2018; Zdravković et al., 2009; Đokić & Stojanović, 2010; Ostojić et al., 2011). Knowing, on the basis of a greater number of studies, that obesity among children and adults leads to metabolic disorders, increased blood pressure, type 2 diabetes, coronary conditions, liver disease and the onset of cancer (Corey & Kaplan, 2014; Ogden et al. 2016; Ghanemi & St-Amand, 2018), the proper manner and solution for the prevention of a further increase in the prevalence of overweigh and obesity should be found. Attempts should also be made to decrease the percentage of obesity primarily among children but also among adults, with a change in the approach to this health problem. The results of certain studies have indicated that in southern European countries, approximately 40% of children under the age of 10 are overweight or obese, while in the northern countries of Europe, that number is less than 10% (Prentice, 2005; Cattaneo et al., 2010). In a national representative study in Sweden, carried out on a population of 4538 participants aged 7-9, only 3% were obese (Sjöberg et al., 2011). Based on these data, and knowing that the nutritional level of children is one of the more important indicators of their health, psycho-physical abilities as well as potential for normal growth and development, the solution should be found in a different approach and attitude towards this health problem, modelled perhaps on the system and life habits of the nations of northern European countries, which would be implemented in our environment.

CONCLUSION

The study has shown the dynamic through which the morphological characteristics change, and at the same time indicated the differences in the morphological characteristics of boys aged seven to ten, depending on their nutritional status. Insight into the results of their morphology and its evaluation indicated significant differences in almost all the measured parameters of the participants.

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TREND PROMENE MORFOLOŠKIH KARAKTERISTIKA DEČAKA STAROSTI 7-10 GODINA

Cilj ovog istraživanja bio je da se odredi trend promena morfoliških karakteristika dečaka starosnog doba od 7 do 10 godina različitog stepena uhranjenosti sa akcentom na trned pojave gojaznosti kod dečaka starosti od 7 do 10 godina. Ukupan uzorak sačinjavalo je 1164 dečaka, raspoređenih u četiri subuzorka u odnosu na godine starosti SU1, SU2, SU3, i SU4), a potom je svaki subuzorak podeljen na tri grupe u zavisnosti od stepena uhranjenosti. Utvrđivana su četiri morfološka faktora: longitudinalna, transverzalna i cirkularna dimenzionalnost skeleta, i masa tela i potkožno masno tkivo, i pomoću njih su se utvrđivale morfološke karakteristike ispitanika. Obrada podataka izvršena je statističkim programom SPSS 20.0. Za utvrđivanje dinamike promena u rastućem ili opadajućem kontinuumu korištena je trend analiza. Inspekcijom i evaluacijom rezultata dobijenih u ovom istraživanju utvrđene su razlike u morfološkim karakteristikama kod normalno uhranjene, prekomerno uhranjene i gojazne dece različite starosti. Dinamika promena gorepomenutih karakteristika u većini prostora morfologije dečaka pokazuje kontinuiranu formu rasta sa uzrastom ispitanika. Kod ispitanika sa normalnom i prekomernom telesnom masom nije uočena diskontinuirana forma rasta morfoloških karakteristika. Diskontinuirana forma rasta je vidljiva kod gojaznih ispitanika u prostoru koji se odnosi na merenje potkožnog masnog tkiva. Vidljiv je i znatno veći porast telesne mase na godišnjem nivou u odnosu na prosek.

Ključne reči: *građa tela, mlađi školski uzrast, gojaznost, rast, razvoj*

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Review article

EXPLOSIVE POWER IN BASKETBALL PLAYERS

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Abstract. *Explosive power in basketball is manifested through various variants of jumps, starting acceleration, sudden changes in direction, deceleration, sudden stops and passing. The aim of this research is to identify and sum up the relevant literature published in the period from 2000 to 2019, focusing on the explosive power of basketball players, and to explain relations between training programs and explosive power development. The results confirmed that explosive power is a significant characteristic of professional basketball players and one of the most important factors for achieving top results. The results show that in spite of the inborn coefficient, the development of explosive power can be realized through planned, rational and well-organized training. A positive correlation was determined between explosive power and running at short distances, jumps and throwing, as well as between explosive power and lean body mass in basketball players of different ages. It is necessary to give greater attention to the training of explosive power, because it is an effective means that contributes to the efficiency of the basketball player.*

Key words: *Basketball, Explosive strength, Vertical Jump, Speed, Agility*

INTRODUCTION

Basketball is a high-intensity team sport with alternative phrases of high load, and success in basketball requires technical, tactical and physical preparation. In basketball, explosive power is manifested through various variants of jumps, starting acceleration, sudden changes in direction of movement, deceleration, sudden stops and passing. Knowing the explosive power of basketball players of different ages is in direct relation with the effects of training, and it also makes the choice of methods easier for the coach, along with the process of planning and programming (Aksović & Berić, 2017). In the first place, explosive power depends of the number of active motor units, genetic conditionality makes

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up about 80% and it is defined as the ability of an athlete to produce the highest possible force in the shortest possible time (Zatsiorsky & Kraemer, 2009).

Numerous examples of research of the explosive power of basketball players of different ages are found around the world (Maffiuletti et al., 2000; Santos & Janeira, 2008; Khlifa et al., 2010; Santos & Janeira, 2011, 2012; Kocić, Berić, Radovanović, & Simović, 2012; Snyder et al., 2018; Arede, Vaz, Franceschi, Gonzalo-Skok, & Leite, 2018). In sports such as basketball, explosive power is one of the most significant factors for achieving great sports results (McBride, Triplett-McBride, Davie, & Newton, 2002; Carlock et al., 2004; Latorre Román, Villar Macias, & García Pinillos, 2018; Hernández et al., 2018). The reason for that is today's basketball demands require players with highly developed motor abilities. For one half of time the player jumps about 16-17 times, and when we count it, we get 35 times during the whole match (Narazaki, Berg, Stergiou, & Chen, 2009). Köklü, Alemdaroğlu, Ünver Koçak, Erol, & Findikoğlu (2011) discovered the differences between the lower extremities of basketball players from Turkish I and II leagues and they showed huge differences in their performances which depended of their playing position on the team. The basketball players who belong to the category of younger players (10-12 years old), train to develop explosive power in different ways, through different ways of moving, through the play, and in this way the body makes itself more resistant, and explosive power is developed in short sprints. Young basketball players (13-14 years old) can be influenced the most in terms of explosive power development with minimal outside loads. In later ages (15-16 years old) the outside load possibilities increase (Pavlović, 2007). It is also familiar that growth and the maturing process among men have a positive effect on developing explosive power. Explosive power in that period is positively related with chronological age, constitution and variation in body weight (Bosco, 1994).

During the last few years, trainers have recognized the significance of explosive power such as the sprint, since in the past they were convinced that the speed of running is genetically conditioned and that it cannot be improved by training (Moreno, 1994). Today, genetics are considered as one of the factors for determining the maximal speed of the potential athlete. Zhang (2013) examined explosive power, running speed on short distances, strength resistance, and pointed out the positive effect on the explosive power of the lower extremities and endurance in general. Thus, it is necessary that this type of endurance training be specially designed for young basketball players and increase the development of explosive power which is a very important factor for reaching top sports results (Ademović, Kocić, Berić, & Daskaloski, 2015). Thus, it is routine training which should be given the certain time interval for explosive power development, especially during the preliminaries (Pauletto, 1994).

The aim of this research is to identify and sum up the relevant literature published in the period from 2000 to 2019 which focused on the explosive power of basketball players, and to explain the relations between training programs and explosive power development.

METHODS

The database sources and the research strategy

The electronic search of papers was done in the next databases: PubMed, ScienceDirect and Google Scholar. The researched papers were published on the SCI list in the period

between 2000 and 2019. The search was conducted by a combination of terms, which are first of all related to the area of explosive power among the players. In order to get papers related to this topic, the search was limited on certain keywords: "explosive power", "explosive strength", "basketball players", "plyometric training", "resistance training", and "training".

The descriptive method was used to analyze the obtained data. All the titles and abstracts were reviewed for the potential papers which could be included in the systematic review. The lists of previous and original studies were also reviewed. Relevant papers were obtained when they met the criteria for = inclusion, after a detailed search. Whereever = possible, the strategy of the search was modified and adapted to each database with the aim of increasing the sensitivity of the research.

A systematic review of the papers is shown according to methodological instruction and in accordance with the consensus of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses-PRISMA (Moher, Liberati, Tetzlaff, & Altman, 2009).

The criteria for inclusion

Type of study:

Randomized controlled and non-randomized studies were examined and included in further analysis, while uncontrolled studies were excluded. Papers that were published in English and Serbian were included in the study.

The sample of participants:

Professional basketball players, aged 13-28, without any acute or chronic diseases.

Type of intervention:

If the studies confirmed the effects of training they were included if the training program lasted four weeks or more.

The type of obtained results:

The primary result to be included in the systematic review was explosive power. The secondary results consisted of motor abilities in correlation with explosive power, the concentration of lactate, body composition, fatigue before and after training of explosive power, and VO2max in correlation with explosive power.

Criteria for exclusion

The type of study: 1) studies in which the participants suffered from some acute or chronic disease; 2) studies written in a language other than English or Serbian; 3) studies without a control group or experimental group; 4) duplicates; 5) studies involving a program with a duration of less than four weeks.

RESULTS

Initially, there was 63 prospective papers identified and six additional ones, according to their references. After deleting duplicates and after paper elimination due to their titles, the number of studies remaining was 34. These papers were examined in detail and 24 of them satisfied the given criteria to be included in the systematic review.

The total number of research participants from 24 of the papers included in the systematic review was 1186, and of this number 870 were male and 316 female. 18 studies (Maffiuletti et al., 2000; Trninić, Marković, & Heimer, 2001; Castagna et al., 2007; Santos & Janeira, 2008, 2011, 2012; Castagna, Chaouachi, Rampinini, Chamari, & Impellizzeri, 2009; Khlifa et al., 2010; Tsimahidis et al., 2010; Casartelli, Müller, & Maffiuletti, 2010; Zemková & Hamar, 2010; Shalfawi, Sabbah, Kailani, Tønnessen, & Enoksen, 2011; Stojanović, Ostojić, Calleja-González, Milosević, & Mikić, 2012; Marić, Katić, & Jeličić, 2013; te Wierike et al., 2014; Rodriguez-Rosell, Mora-Custodio, Franco-Márquez, Yáñez-García, & González-Badillo, 2016; Snyder et al., 2018; Gonzalo-Skok, Sánchez-Sabaté, Izquierdo-Lupón, & Sáez de Villarreal, 2019) included all male participans, five studies included female participans (Delextrat & Cohen, 2009; Erculj, Blas, & Bracic, 2010; Noyes, Barber-Westin, Smith, Campbell, & Garrison, 2012; Battaglia, Paoli, Bellafiore, Bianco, & Palma, 2014; Bouteraa, Negra, Shephard, & Chelly, 2018), and one of the studies included both male and female participants (Garatachea et al., 2014).

Three of the studies included not only basketball players as a sample, they also included volleyball (Battaglia et al., 2014), football players (Rodriguez-Rosell et al., 2016), and resistance-trained adult men (Snyder et al., 2018).

Twelve of the studies were aimed at determining the effects of training on the development of explosive power. The most common duration of the training program (in 5 studies) was 10 weeks (Santos & Janeira, 2008, 2011, 2012; Khlifa et al., 2010; Tsimahidis et al., 2010), and after that in three studies the program lasted for 6 weeks, (Zemková & Hamar, 2010; Noyes et al., 2012; Gonzalo-Skok et al., 2019), in two studies 8 weeks (Trninić et al., 2001; Bouteraa et al., 2018), in one study program duration four weeks (Maffiuletti et al., 2000), and one study aimed to determine the influence of three years of a sport-specific training background (SSTB) program (Battaglia et al., 2014).

Two studies aimed to determine the validity and reliability of measuring instruments for estimating explosive power (Casartelli et al., 2010; Rodriguez-Rosell et al., 2016).

Table 1 Systematic review of the studies dealing with the explosive power of basketball players

Ref.	Population	Sample (gender, number, groups, age, BH, BM, BE)	Measuring instruments	The aim of the research	Results
Maffiuletti et al. (2000)	Basketball players competing in division 2 of the French Basketball Federation	M: n=20, EXP: n=10, CON: n=10, Aged: 24.7±3.9 years, BH: 193.9±6.9 cm, BM: 87.8±8.9 kg, BE: 6-10 years	SJ, CMJ	To investigate the influence of a 4-week electromyostimulation training program on the strength of the knee extensors and the vertical jump performance of 10 basketball players	Isokinetic strength ↑ concentric and eccentric contraction speed. ET ↑↑ isometric strength at the two angles adjacent to the training angle, SJ ↑↑ 14% at week 4. CMJ NC

Trninić et al. (2001)	Cadet basketball players of the B.C. "Cibona"	M: n=12, Aged: 15.0-16.0 years, BE: 4-6 years	SAR, SIT, PUSH, FLEX, PULL, AG20, AN300	To determine the effects of the applied developmental training programme on some basic and specific motor-functional abilities of talented cadet basketball players during two months of the competitive season	At the multivariate level ↑↑ changes. Differences ↑↑ SAR, AG20, PUSH, SIT ↑ AN300, FLEX
Castagna et al. (2007)	Junior basketball players of the regional Italian Adriatica Junior Basket League	M: n=18, Aged: 16.8±1.2 years, BH: 181.3±5.7 cm, BM: 73±10 kg, BE: at least 5 years	Shuttle run sprints, basketball-specific repeated-sprint ability protocol consisting of ten 15-m shuttle run sprints with 30 s of passive recovery	To examine the effects of maximal aerobic power (VO2max peak) level on the ability to repeat sprints in young basketball players	Blood lactate concentrations before and after training 2.5±0.7, 13.6±3.1, and 14.2±3.5 mmol·L-1. A negative correlation between the first sprint and RSAFI. NC correlation between VO2max and RSAFI. VO2max is not a predictor of repeated-sprint ability
Santos & Janeira (2008)	Young basketball players	M: n=25, EXP: n=15, Aged: 14.7±0.5 years, BH: 175.9±9.3 cm, BM: 72.7±16.9 kg, BE: 5.6±2.6 years, CON: n=10, Aged: 14.2±0.4 years, BH: 173.2 ±7.6 cm, BM: 61.1±11.4 kg, BE: 4.03±1.2 years	SJ, CMJ, ABA, DJ, MBT, MP	To evaluate the effects of a complex training program, a combined practice of weight training and plyometrics on the explosive strength development of young basketball players	EXP ↑ SJ, CMJ, ABA, MBT. CON ↓ CMJ, ABA, MP ↑ MBT
Castagna et al. (2009)	Italian regional-level amateur basketball players	M: n=22, Senior: n=11, Aged: 24.5±3.5 years, BH: 192.2.3±8.82 cm, BM: 84.4±11.41 kg, Junior: n=11, Aged: 16.7±1.2 years, BH: 180.75±5.85 cm, BM: 69.25±5.85 kg	VO2max, fitness test (Yo-Yo) CMJ, SL	To examine the aerobic fitness and lower-limbs explosive power abilities of Italian regional-level amateur basketball players	VO2max in both groups CMJ, ABA, and MP ↑ The differences between seniors and juniors in CMJ, SL. NC between the groups on the fitness test (Yo-Yo)

Delextrat & Cohen (2009)	Basketball players of the English National League Division 2	F: n=30, Aged: 25.2±3.7 years, BH: 174.5±5.4 cm, BM: 68.2±.9 kg, BE: min 2 years, Divided into 3 groups: guards (positions 1 and 2), forwards (positions 3 and 4), and centers (position 5).	30-second Wingate Anaerobic test (WAnT), isokinetic testing of the knee extensors, 2 types of jump tests, a 20-m sprint, the agility T-test, a suicide run, and a basketball chest pass	To investigate the effect of playing position on strength, power, speed, and agility on the performances of women basketball players	Guards better than centers for the relative peak and mean power during the WAnT, relative peak torque of knee extensors, SLJ, suicide run, agility T-test. Guards have better performances than forwards in the suicide run test, forwards greater peak torque of the knee extensors compared to centers
Casartelli et al. (2010)	Healthy basketball players of the regional and national Swiss basketball championships	M: n=44, Aged: 15.3±3.8 years, BH: 178±18 cm, BM: 68±18 kg	SJ, CMJ, RJs	To verify the validity and reliability of the Myotest accelerometric system (Myotest SA, Sion, Switzerland) for the assessment of vertical jump height	The Myotest-T is a valid and reliable method for the assessment of vertical jump height, and its use is legitimate for field-based evaluations, whereas the Myotest-V is neither valid nor reliable
Erčulj et al. (2010)	Young elite European basketball players	F: n=65, Aged: 14.49±0.61 years, BH: 172.6±8.0 cm, BM: 62.24±7.3 kg, BE: 5.9±1.9 years	CMJ, DJ 25cm, DJCT, sprint 20 m, sprint dribble 20 m, 6 x 5 m sprint, 6 x 5 m sprint dribble, BBT, MBT	To determine and analyze the level of certain motor abilities (acceleration and agility, the explosive strength of the arms, and take-off power) of young elite European female basketball players	The division of basketball had better results than A and B division. Differences in the tests: 6 x 5 m sprint dribble, MBT, 20 m sprint
Shalfawi et al. (2011)	Professional basketball players	M: n=33, Aged: 27.4±3.3 years, BH: 192.5±8.2 cm, BM: 89.8±.11.1 kg, BE: min 2 years	SJ, CMJ, 10 m, 20 m, 40 m sprint	To examine the relationship between vertical jump measures and sprint speed over 10, 20, and 40 m among professional basketball players	Positive correlation SJ, CMJ ↑ to running performance 10 m, 20 m, 40 m. NC correlation jumping performance peak powers and reactive strength running speed

Khlifa et al. (2010)	Tunisian First Professional Division basketball players	M: n=27, EXP1: n=9, EXP2: n=9, CON: n=9, Aged: 23.61±0.96 years, BE: 12.4±3.5 years	SJ, CMJ, 5JT	To examine the effect of a standard plyometric training protocol with (EXP1) or without added load (EXP2) in improving vertical jumping ability in male basketball players	SJ, CMJ, 5JT LPG ↑↑ PG ↑
Tsimahidis et al. (2010)	Junior basketball players	M: n=26, EXP: n=13, Aged: 18.0±1.2 years, BH: 183.0±1.3 cm, BM: 80.9±10.2 kg, BE: 5.2±2.1 years, CON: n=13, Aged: 18.0±0.7 years, BH: 186.0.2±6.1 cm, BM: 82.0±5.3 kg, BE: 6.1±1.4 years	5 sets of 8-5 (RM), SJ, DJ, CMJ, sprint 10 m, 30 m	To investigate the effect of a 10-week heavy resistance combined with a running training program on the strength, running speed (RS), and vertical jump performance of young basketball players	EXP ↑ RM, SJ, DJ, CMJ, sprint 10 m, 30 m. CON, NC. CTP is beneficial for strength, RS, and jump height. At the final measuring there were differences between groups for all the variables
Zemková & Hamar (2010)	Elite basketball players	M: n=34, EXP: n=17, CON: n=17	Agility, balance (wobble board with eyes open and eyes closed), speed of step initiation, strength differentiation accuracy, and explosive power (10-seconds maximal jumps CMJ, SJ, DJ)	To evaluate the effect of 6-week combined agility-balance training on neuromuscular performance in basketball players	Combined agility-balance training ↑ dynamic balance visual control, eyes closed conditions, run-out speed, reduced ground contact time during DJ, and improved ability to differentiate the force of muscle contraction during repeated jumps. Balance exercises ↑ neuromuscular performance CON, NC
Santos & Janeira (2011)	Young basketball players	M: n=24, EXP: n=14, Aged: 15.0±0.5 years, BH: 172.9±6.3 cm, BM: 62.6±9.9 kg, BE: 7.07±2.8 years, CON: n=10, Aged: 14.5±0.4 years, BH: 173.2±7.6 cm, BM: 61.1±11.4 kg, BE: 4.03±1.2 years	SJ, CMJ, ABA, DJ, MBT, MP	To determine the effects of (a) plyometric training on explosive strength indicators in adolescent male basketball players and (b) detraining and reduced training on previously achieved explosive strength gains	EXP ↑ SJ, CMJ, ABA, DJ, MBT, MP. Detraining and a reduced training program indistinctly contribute to maintenance of strength levels

Santos & Janeira (2012)	Adolescent basketball players	M: n=25, EXP: n=15, Aged: 14.5±0.6 years, BH: 172.7±8.1 cm, BM: 61.6±8 kg, BE: 5.0±2.4 years, CON: n=10, Aged: 14.2±0.4 years, BH: 173.2±7.6 cm, BM: 61.1±11.4 kg, BE: 4.3±1.2 years	SJ, CMJ, ABA, DJ, MBT	To assess the effects of a lower- and upper-body 10-week in-season resistance training program on explosive strength development in young basketball players	EXP ↑ SJ, CMJ, ABA, DJ and MBT. CON ↓ CMJ, ABA, DJ and MBT. Groups similar on the pretest, but significant differences occurred on the posttest in all the variables
Noyes et al. (2012)	High school basketball players	F: n=57, Aged: 14.0-17.0 years, BH: 170.0±6.7 cm, BM: 60.7±10.1 kg, BMI: 20.3±3.4, BE: 5.2±2.1 years	DJ, multistage fitness test, VJ, 18 m sprint	To determine if a sports-specific training program could improve neuromuscular and performance indices in female high school basketball players	VO2max, DJ, VJ ↑↑ NC 18 m sprint
Stojanović et al. (2012)	Elite basketball players	M: n=24, Aged: 22.2±3.4 years, BH: 197.1±6.2 cm, BM: 95.7±8.8 kg, BE: 11.0±3.1 years	CMJ, and incremental pseudo-ramp test protocol with measured CMJ height and VO2max, RSA (RSAFI, RSAtot)	To examine the relationship between explosive strength and aerobic power with basketball specific repeated sprint ability in elite male basketball players	↓↓ performance for the sprint at 30 m occurred after eight sprint No significant correlation between RSA and VO2max. strong inverse correlation between CMJ height and RSA
Marić et al. (2013)	Cadet basketball players from Herzegovina members of the five first-league clubs	M: n=83, Aged: 13-15 years, BH: 174.8 cm, BM: 63.6 kg, BMI: 20.81, BE: 2-4 years	3 tests for the evaluation of explosive strength (SBJ, sprint to 20 m from a low starting point, MBT), 9 tests for evaluation: coordination, speed, flexibility, repetitive strength, static strength, precision, and five tests for evaluation of specific motor skills	To determine whether there is a correlation between motor and specific motor skills	The impact of basic motor abilities of precision and balance on specific abilities of passing and shooting precision and ball handling underlies the second linear combination. Ball handling has the largest impact on player quality in basketball cadets followed by shooting precision and passing precision

te Wierike et al. (2014)	Dutch Basketball Academy elite players	M: n=48, EXP: n=32, Aged: 16.0±1.7 years, CON: n=16, Aged: 16.1±1.8 years, BE: 6.4±2.1 years	SST for RSA, the VJ for lower body explosive strength (power), and the ISRT for interval endurance capacity, body composition was estimated (PF, LBM)	To determine whether repeated sprints affect the development of explosive strength and body composition in elite basketball players	Age, lower body, explosive strength, and interval endurance contributed to RSA. Explosive strength of the lower extremities ↑ RSA with age. NC between groups, the positive correlation LBM and explosive strength of the lower extremities
Garatachea et al. (2014)	Elite basketball players of the Spanish league	M, F: n=383, EXP: n=100 (60 male, 40 female), CON: n=283 nonathletic (216 male, 67 female), Aged: n.d., BH: n.d., BM: n.d., BMI: n.d., BE: n.d.	SJ, CMJ	To determine the association of the ACTN3 R577X polymorphism with leg-muscle explosive power in Spanish elite basketball players	NC between groups, ACTN3 R577X polymorphism. NC influenced the explosive power of the players
Battaglia et al. (2014)	Young basketball and volleyball players	F: n=31, Basketball players: n=10, Aged: 15.60±1.34 years, BMI: 22.67±3.13, Volleyball players: n=10, Aged: 14.50±0.97 years, BMI: 22.17±1.87, CON: n=11, Aged: 15.00±0.52 years, BMI: 21.10±2.09	SJ, CMJ, CMJ-AS, SCPT, SBOMBT	To evaluate the influence of 3 years of sport-specific training background (SSTB) on the vertical jump and throwing performance in young female basketball and volleyball players	SJ, CMJ, CMJ-AS, Volleyballers group showed a higher vertical jump performance than basketballers and CON. Voleyballers ↑ flight time and jump height SJ, CMJ, CMJ-AS. Basketballers and volleyballers better results in the SCPT, SBOMBT compared to the CON group. The correlation between the ↑↑ CMJ-AS, SBOMBT in the 3 groups

Rodriguez-Rosell et al. (2016)	Basketball and soccer players of 3 different age categories	M: n=186, Basketball players: n=59, in 3 different age categories (>15 years, <15 years, and adults), Soccer players: n=127, in 3 different age categories (>15 years, <15 years, and adults)	20 m sprint, CMJ, ABA, 2-LEGS, 1-LEG	To analyze the reliability and validity of 2 standardized (CMJ, ABA) and 2 sport-specific (2-LEGS, 1-LEG take-off jump) vertical jump tests, and their usefulness as predictors of sprint and strength performance for soccer and basketball players in 3 different categories	CMJ, ABA high intraclass correlation coefficients and low coefficients of variation, 1-LEG lowest absolute and relative reliability. 1-LEG lowest associations with sprint and strength performance. CMJ and ABA are the most reliable tests for the estimation of explosive force in soccer and basketball players
Snyder et al. (2018)	Resistance-trained adult men and adolescent basketball players	M: n=20, Resistance-trained adult men: n=10, Aged: 22.6±1.6 years, BH: 180±10cm, BM: 85.7±8.6 kg, Adolescent basketball players: n=10, Aged: 16.5±0.7 years, BH: 178±0.7 cm, BM: 69.5±9.1 kg	CMJ, DJ	To compare different methods for assessing plyometric ability during the countermovement (CMJ) and drop jumps (DJ) in a group of adults and adolescents.	Adults jumped ↑ adolescents, CT decreased from CMJ to DJ. WNORM, PONORM durin g CMJ were less during RSI ↑ CMJ to DJ, plyometric indices decreased significantly. RSIMOD, RSI contributed significantly to the prediction of JH during CMJ and DJ. PWI was able to explain ≥68% of the variance in JH.
Bouteraa et al. (2018)	Adolescent basketball players of the regional level	F: n=26, EXP: n=16, Aged: 16.4±0.5 years, CON: n=10, Aged: 16.5±0.5 years	SJ, CMJ, DJ, 5, 10 and 20-m sprints, SBT, YBT, MICODT	To examine the effect of 8 weeks combined balance and plyometric training on the physical fitness of female adolescent basketball players	NC differences in SJ and CMJ. EXP ↑↑ DJ. NC differences SBT, YBT significant group interaction. EXP ↑ MICODT

Gonzalo-Skok et al. (2019)	Young basketball players	M: n=20, EXP1: n=10, EXP2: n=10, Aged: 13.2±0.7 years, BH: 172.9±7.9 cm, BM: 59.5±12.7 kg	LST,VJ, HJ, V-cut and 5+5 m with a 180°COD test, an ankle dorsiflexion test and dynamic balance tests	To compare the influence of a combined jumping direction and force application (horizontal-unilateral vs. vertical-bilateral) plyometric training on linear sprinting, jumping, change of direction and dynamic balance in young elite basketball players.	Within-group differences in unilateral VJ, HJ, V-cut test and posterior-lateral direction with the right leg. EXP1 ↑ LST, posterior-lateral direction with the left leg. EXP2 ↑ anterior direction with the left leg. Between group ↑ 10-m, V-cut test in EXP1 than in EXP2.

Legend: M-Males; F-Females; EXP-Experimental group; CON-Control group; BH-Body height; BM-Body mass; BE-Basketball experience; VJ-Vertical jump; HJ-Horizontal Jump; SJ-Squat jump; ET-Electromyostimulation training; CMJ-Counter movement jump; CMJ-AS-Counter movement jump with arm swing; DJ-Depth jump; DJ25CM-Drop jump 25 cm; DJCT-Drop jump contact time; SSTB-Sport-specific training background; SL-Stiff-leg jumps; SLJ-Single-leg jump; WAnT-Wingate anaerobic test; ABA-Abalakov test; SBJ-Standing broad jump; 5JT-5 jump test; SAR-Standing vertical jump with arms swing; MP-Mechanical power; PF-Percent fat; LBM-Lean body mass; BBT-Seated basketball ball throw; MBT-Seated medicine ball throw; SST-Shuttle sprint test; ISRT-Interval shuttle run test; SCPT-Seated chest pass throw; SBOMBT-Seated backward overhead ball throw; RSA-Repeated sprint ability; RSA_{tot}-Repeated sprint ability-summation of 10 sprint times; RM-Repetition maximum; RSA_{FI}-Repeated Sprint Ability-fatigue index; RJs-Repeated jumps; SIT-Sit-ups in 60 seconds; PUSH-Push-ups; FLEX-Sit-and-reach; PULL-Overgrip pull-ups; AG20-20-yard drill; AN300-300 yard shuttle run; VO2max-Maximal oxygen uptake; W_{NORM}-Normalized work; PO_{NORM}-Power output; PWI-Propulsion work; CT-Contact time; SBT-Stork Balance Test; YBT-Y-Balance Test; MICODT-Modified Illinois Change of Direction Test; COD-Change of direction; LST- Linear sprinting test; NC-No statistically significant changes $p>0.05$; ↑-Statistically significant increase $p<0.05$; ↑↑-Statistically significant increase $p<0.01$; ↓-Statistically significant decrease $p<0.05$; ↓↓-Statistically significant decrease $p<0.01$.

DISCUSSION

This research was aimed at analyzing and processing the explosive power of basketball players of different ages. It encompassed studies on the effects of programs of explosive power performed through jumps, throws and sprints, that lasted for about four weeks and more (Maffiuletti et al., 2000; Trninić et al., 2001; Santos & Janeira, 2008, Khlifa et al., 2010; Tsimahidis et al., 2010; Zemková & Hamar, 2010; Santos & Janeira, 2011, 2012; Noyes et al., 2012; Battaglia et al., 2014; Bouteraa et al., 2018; Gonzalo-Skok et al., 2019) and showed that despite the high coefficient, which is congenital, explosive power can be developed through good organized training which should be conducted methodically, rationally and in a well-organized manner.

Among the basketball players plyometric training alone and in combination with other methods is recommended as a primary means in the training process (Aksović, Berić, Kocić, Jakovljević, & Milanović, 2019) with the goal to develop explosive power (Santos & Janeira, 2011; Snyder et al., 2018; Gonzalo-Skok et al., 2019). Gonzalo-Skok et al. (2019) showed that 6-weeks of combined jumping and force oriented plyometric training leads to statistically significant improvement in explosive power, linear sprinting, change of direction speed and dynamic balance among young basketball players. Similar results

were obtained among female basketball players. Bouteraa et al. (2018) show that the addition of the 8-weeks of balance and plyometric training to regular in-season basketball training is a safe and feasible intervention that enhances the vertical jump height, balance, and agility in female adolescent basketball players. Also, the effect of complex and resistance training was confirmed in the study of Santos & Janeira (2008, 2012).

The results of this study stress that explosive power is the most significant characteristic of professional basketball players, and the most important factor in achieving top sports results. One basketball match consists of 46±12 jumps per one player (Mclennes, Carlson, & McKenna, 1995) which indicates the significance of explosive power. Explosive power in basketball is manifested through different jumps, start acceleration and the change of direction, deceleration, and passing of the ball. It is why it represents a very attractive field for research (Castagna et al., 2009; Casartelli et al., 2010; Battaglia et al., 2014). Several studies show the significant differences in jumps height between the basketball players of different levels of competition (Hoare, 2000; Delextrat & Cohen, 2009). They show that the best players on the team have a tendency to jump more than others. The research shows that if the player plays the whole match he runs over about 6000-7000 m, and makes 40 different jumps, 280 changes in direction, 120 ball catches, and 80 ball passes. For this reason Stojanović et al. (2012) point out that coaches should spend more time on explosive power development in elite basketball players, since it has a huge influence on their competitive success.

The research points to a positive correlation of jumps and throws (the three most commons ways of giving a ball to others are from the chests, above head and baseball transferring) among basketball players of different ages (Santos & Janeira, 2011; Battaglia et al., 2014). By using a medicine ball, the development of explosive strength of the upper extremities could be increased (Gambetta, 1986). The positive correlation is determined between the explosive power and running on short distances (Stojanović et al., 2012; te Wierike et al., 2014). However, Shalfawi et al. (2011) concluded that there is no relation between vertical jump height and short sprint time that are considered the most important predictors for success in basketball. Zemková & Hamar (2010) indicate that a combined 6-week training has a positive effect on agility, balance, running speed, and muscle strength increase during the execution of vertical jumps.

Delextrat & Cohen (2009) in their study aimed to examine the role of the team's position on strength, power, speed and agility. They determined that guards are better than centers at performing the Wingate Anaerobic test, Single-leg jump, agility T-test, and suicide run test. On the other hand, guards are better than forwards at performing the suicide run test, and forwards are better than centers in isokinetic testing of the knee extensors.

It should be announced that during the performance of the mentioned tests some injuries can occur and it is proven that the frequency of injuries depends of the player's position on the team. The most common players with injuries are shooting guards (47.8%), centers (34.7%), and point guards (17.4%). Age, height, body mass and the training time represent the risk factors for the shooting guards, while for point guards the biggest risk factor is body mass. Except this, individual characteristics and training may be related to the risk factors of the player's position 1, 2, 3, 4, 5 (guards, forwards, and centers) and the body mass is the risk factor for the players in all positions (Vanderlei et al., 2013).

The sttudy of Casartelli et al. (2010) confirmed the validity and reliability of the Myotest-T flight time, i.e., accelerometric system measuring instrument for evaluating explosive

power (Myotest SA, Sion, Switzerland). However, the hand test Myotest-V (vertical takeoff velocity) is not considered as a valid and reliable one. The counter movement jump and Abakalov test (CMJ, ABA) are reliable for evaluating the explosive power of basketball and football players (Rodriguez-Rosell et al., 2016). It should also be announced that the volleyball players obtain better results in performing vertical jumps when comparing basketball players and a control group (Battaglia et al., 2014). No significant correlation between VO_{2max} and repeated sprint ability was found, and can be explained by the lack of phosphocreatine that is fundamental in the performance maintenance in repeated 6s sprinting and $VO_{2max.}$ Additionally, a strong inverse correlation between Countermovement jump height and repeated sprint ability was found. Improvements in repeated sprint ability could be expected after prolonged explosive strength training (Stojanović et al., 2012). Wierike et al. (2014) determined a moderate but positive correlation of the repeated sprint ability and explosive strength of the lower body (r=.35), a moderate but positive correlation of explosive power with lean body mass (r=0.44), and a small but positive correlation between repeated sprint ability and lean body mass (r=0.23) in adolescent basketball players. According to them, repeated sprint ability is significantly influenced by explosive strength and age (improved between 14-17 years at the level $p \leq 0.05$ and reached a plateau at 17–19 years).

CONCLUSION

The results of this study confirmed previous findings that explosive power is a significant characteristic of basketball players and that it is one of the most important factors for achieving top sports results. In spite of the inborn coefficient, the development of explosive power can be realized through planned, rational and well-organized training. A positive correlation between explosive power and running on short distances, jumps and throwing was determined, as well as between explosive power and lean body mass in basketball players of different ages. Motor test performance depends on playing positions on the team and can lead to injuries. It is necessary to give high attention to the training of explosive power, because it is an effective means that contributes to the efficiency of the basketball player.

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EKSPLOZIVNA SNAGA KOŠARKAŠA

Eksplozivna snaga u košarci manifestuje se kroz različite varijante skokova, startnog ubrzanja, naglih promena pravca, usporavanja, naglih zastoja i dodavanja. Cilj ovog istraživanja je da se identifikuje i sumira relevantna literatura objavljena u periodu od 2000. do 2019. godine, usredsređena na eksplozivnu snagu košarkaša i da se objasni odnos između programa treninga i razvoja eksplozivne snage. Rezultati su potvrdili da je eksplozivna snaga značajna karakteristika profesionalnih košarkaša i jedan od najvažnijih faktora za postizanje vrhunskih rezultata. Rezultati pokazuju da se uprkos koeficijentu urođenosti razvoj eksplozivne snage može realizovati planiranim, racionalnim i dobro organizovanim treninzima. Utvrđena je pozitivna povezanost između eksplozivne snage i trčanja na kratke razdaljine, skokova i bacanja, kao i između eksplozivne snage i bezmasnog tkiva košarkaša različitih starosti. Potrebno je posvetiti veliku pažnju treningu eksplozivne snage, jer je to efikasno sredstvo koje doprinosi efikasnosti košarkaša.

Ključne reči*: košarka, eksplozivna snaga, vertikalni skok, brzina, agilnost*

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Research article

A BOARD MADE OF PLASTIC BOTTLES: A FUNCTIONAL, ECOLOGIC AND ECONOMIC ALTERNATIVE FOR LEARNING STAND UP PADDLE BOARDING

UDC 797.3.012

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Abstract. *The main aim of actual research is to determine whether using the alternative board made of plastic bottles in comparison to conventional board affects the learning and practice of Stand up paddle (SUP) boarding. A sample of 16 healthy participants were recruited for convenience (aged M=23.5 years, CI95%: 21.62–25.54; body height M=170.13 cm, CI95%: 165.00–175.51; body mass M=69.63 kg; CI95%: 62.37–77.72) and randomly assigned to two groups: a) Conventional Material (CM; n=8) and; b) Alternative Material (AM; n=8). As criteria of learning, we considered variables as the number of falls, balance, body control, movement pattern of the paddling and the amount of time required to get stability on the board. No differences between groups in any criteria were found. We also observed that producing a board made of plastic bottles is 20 times cheaper than purchasing a conventional board made of resin. It can be concluded that the recycled board is as functional as a conventional board, but cheaper and less damaging to the environment.*

Key words: *Alternative Materials, Surf, Physical Activity, Water Sport, Sports Learning*

INTRODUCTION

Stand up Paddle (SUP) boarding is a sport modality that includes features from surf and paddling, and has been one of the sports with more practitioners in the last years (Ruess et al., 2013a, 2013b; Schram, Hing, Climstein, & Walsh, 2014). SUP boarding is practiced

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using a surfboard that measures from 3 and 5 meters long per 70 to 90 centimeter wide, and a paddle that is used to move the board across the water (Ruess et al., 2013a; Elling, Kranz, Leikert, & Tresh, 2014; Schram et al., 2014). Practicing SUP boarding providea several physical and mental benefits, since it requires constant activation of most skeletal muscles, such as, the core muscles (Zeni, 2002; Ruess et al., 2013b) and improves mental welfare due to its relaxing effects, which is commonly in aquatic activities (Taylor, Sallis, & Needle, 1985; Ayán, Carvalho, Varela, & Cancela, 2017).

Physical capacities including neuromuscular interaction and body expression are highly implicated in SUP boarding performance. However, the material used in the board confection is also considered an important variable for a good performance of SUP practitioners (Zeni, 2002; Ruess et al., 2013a, 2013b; Schram et al., 2014). So, conventional SUP boards are made of soft and functional materials, such as epoxy resin, fiberglass and expanded polyurethane foam. However, the high cost of these materials (Jesus, Gordilho Neto, Cequeira, Costa, & Santos, 2013) makes the acquisition of a SUP board difficult to the low-income population (Zeni, 2002; Grijó & Baasch, 2003; Carozza, 2013; Schram et al., 2014). Moreover, several chemical processes are implicated in the board confection and around 60% of the discarded materials negatively impact the environment (Grijó, 2004; Grijó & Brügger, 2011; Souza, Machado, Reis, Santos, & Dias, 2013). To minimize environment damage and to facilitate access to the SUP board practice for the low-income population, a Brazilian surfer created a board using plastic bottles. Due to confection facility, this model of the board has been used by different social classes (Glock, 2013; Lumertz, 2015).

Although recyclable materials have been used in different physical activities, including surfboarding (Lumertz, 2015), weight training and functional training (Avelar-Rosa & Figueiredo, 2011; Barros & Oliveira Neto, 2012; Skowronski, 2014), and that different type of materials can affect individual performance on physical activities (Horak, Nashner, & Diener, 1990; Houglum & Bertoti, 2014). However, no studies have been conducted to investigate the effectiveness of recyclable SUP boards on learning and daily practice.

The main aim of the current research is to determine whether using the alternative board made of plastic bottles in comparison to the conventional board affects the learning and practice of SUP boarding.

METHODS

Participants

A sample of 16 healthy participants were recruited for convenience (aged M=23.5 years, CI95%: 21.62–25.54; body height M=170.13 cm, CI95%: 165.00–175.51; body mass M=69.63 kg; CI95%: 62.37–77.72). The criteria for participation in the study were no previous experiences with surfboard activities. And, in order to minimize error, no participants with motor or learning disfunctions were included in this study. The participants were randomly assigned to two groups: a) Conventional Material (CM; n=8) and; b) Alternative Material (AM; n=8). All of the participants were informed of all procedures and the aim of this study, and gave informed consent before beginning the study. All procedures were approved by ethics committee of University of Mogi das Cruzes (#1.082.190/2015).

Materials

To carry out this study, two SUP boards were used, including a conventional board and an alternative board. The conventional board was made of expanded polystyrene foam (EPS), epoxy resin and fiberglass (Seven Seas brand), measuring 307 ×80×11 centimeters (length × width × thickness), with a density of approximately 0.05 gr / cm³ and supported up to 110 kilograms (kg). The alternative board was made of 93 2-liter PET bottles. The dimensions of the alternative board were 290x70x 10 centimeters, with an approximate density of 0.06 gr/cm³ with an adequate support for 100 kg. All participants used similar paddles (198 centimeters long).

Alternative Board

The confection of the alternative SUP board was performed according Lumertz (2015) guidelines. For this, we used 50 whole plastic bottles and 43 cut bottles (removing the top and the bottom). The whole bottoms were air-filled with a manual air pump until their walls were poorly malleable. After this, the exterior tips of the whole bottles, and the interior walls of the cut bottles were sanded with a 120 grit wet sandpaper to provide better adhesion to glue. Finally, the cut bottles were used as connectors to make 7 columns of 6, 7 or 8 whole bottles. An expansive polyurethane glue was used to link the materials.

The bottles of the tip were tilted up to provide a proper angulation to reduce water friction. Soon after, the columns were joined. So, columns with 8 bottles were placed at the center of the board, and the columns were placed on both laterals.

To reinforce the board structure, 6 pairs of 25 mm diameter polyvinyl polychloride (PVC) tubes were fixed between the bottle columns. Thus, two PVC pipes measuring 2.50 meters long were placed between the center columns and a pair with 2.40 meters was put between the columns composed of 8 and 7 bottles. Finally, a pair of 1.80-meter-long tubes were placed between the 7 and 6 bottle columns.

The alternative board deck was made with a 400 x 600 x 5 mm (length x width x thickness) sheet of ethylene vinyl acetate. To fix the deck to the upper surface of the board a contact adhesive was used. Thus, it was possible to improve the grip and reduce irregularities caused by the corrugations of the bottles and tubes used (Figure 1). To ensure the bonding process, the structure was held together with tape and kept at rest for 24 hours.

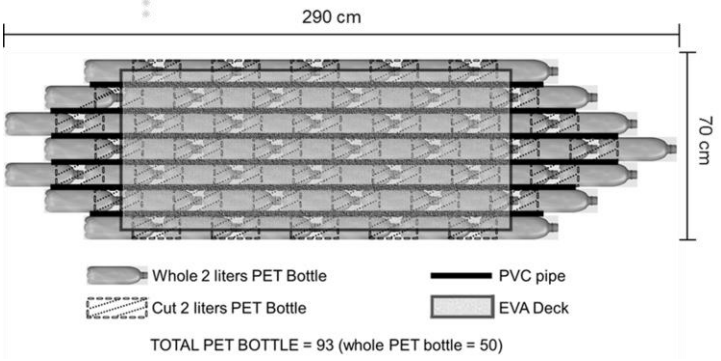

Fig. 1 Project of the PET bottle board

After the glue dried, the flotation and stability of the PET bottle board were tested. To do this, a SUP instructor (mass=90 kg) performed two SUP training sessions in an Olympic pool. In the first session, every 10 minutes of practice, 5 kg of mass was added to the center of the alternative board. The maximum mass supported by the alternative SUP board was 110 kg. During this first stage, the SUP instructor considered that 100 kg is the mass limit for practicing SUP on the alternative board.

In the second session, the SUP instructor performed 30 minutes of practice on the bottle board with 10kg added to the deck (total mass=100kg). After the second stage of the experimental test, the structural consistency of the bottle SUP board was reevaluated. No damage occurred to the structure and we did not notice any conditions that could impair SUP practice or offer any risk to the practitioner, so the alternative board was considered ready for use.

Procedures

We elaborated a learning method based on the guidelines of SUP learning, described in the handbook of Stand-Up Paddle Boarding Award supported by the American Canoe Association (Boys Scouts of America, 2013). Due to a lack of information in the literature about the proper time required for SUP boarding learning, we stipulated a maximum period of 10 days of training with a duration of 40 minutes per day and intervals from 2 to 3 day between sessions. However, the training protocol was considered done when the participants were able to achieve all the requirements properly, including the movement patterns of paddling, body and board control. The whole protocol occurred in a swimming pool that measures 50 × 25 meters (length x width), of a club, of the city of Mogi das Cruzes, São Paulo, Brazil.

In the first session, participants were briefly instructed about the board structure (nose, tail, bottom, deck, deck pad and fin), how to perform the movements properly (paddling and standing up on board). After the introductory instructions, participants were submitted to the practical training of SUP. To familiarize participants with the SUP boarding, we instructed them to start in a kneeling position for the first 10 minutes. Afterwards, they were required to perform the practice standing. In the second session, participants were oriented to start the training in standing position; however, they could start it kneeling if necessary. The sessions were performed with one participant from each group in the swimming pool under favorable weather conditions. During the tasks, participants were instructed to perform the stipulated route in the shortest possible time. Every five minutes instructions and positive feedback about movement pattern were provided to them, respectively.

From the moment that the participant mastered the taught technique, a learning test was applied. And after 15 days without practicing SUP boarding, a retention test was applied to assess persistence on the learned skill was applied. The tests required the participant to go around the swimming pool, bordering it to both the right and left sides. Different criteria were considered, including: a) movement patterns for a proper performance; b) balance (capacity to keep the movement rhythm without body destabilization; c) number of falls; d) time spent to control body movement; e) time used to guide the board and; f) time taken to complete the learning task. In both tests, 2 trials were allowed per participant. A timer was used to register the time spent in both tests. In order to minimize observational bias, all tasks and tests were recorded using 2 digital cameras Samsung (model WB150F, 12 MP) and a digital video camera GoPro (model Hero 3+ Black Edition, 12 MP).

Statistical analysis

Our data were analyzed by the Generalized Estimating Equations test, adjusted for gamma distribution and an unstructured working correlation matrix. The results were analyzed using SPSS statistical software (version 24 for Windows, IBM®). The values were expressed as mean and confidence interval (95% CI).

RESULTS

Motor variables and time of performance

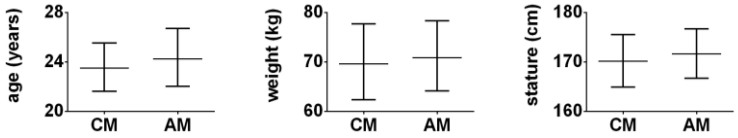

Fig. 2 Mean and confidence interval values (95%) of age, body mass and stature of the groups Conventional Material (CM) and Alternative Material (AM)

In our study, we found that number of falls achieved by CM and AM groups were 4.2 (95% CI: 2.19–8.06) and 3.4 (95% CI: 1.75–6.61), respectively. The number of imbalances in the MA group was 5.71 (95% CI: 3.32–9.85) and in the CM group was 3.5 (95% CI: 2.48–4.93). The mean of session required for the AM group to control body movement was 2.63 (95% CI: 2.18–3.15) and for the CM group it was 2.13 (95% CI: 1.75–2. 58). The required mean of sessions to perform the paddling movement properly was 3 (95% CI: 3.00–3.00) for the MC group and 2.71 (2.40–3.07) for the MA group. Considering the board direction control task, we observed that the mean of days required to guide the board properly was 1.75 (95% CI: 1.14–2.69) for the MC group 1.63 (IC 95 %: 1.21–2.19) for the MA group. In addition, the MA group completed the task in 3.13 (95% CI: 2.90–3.36) sessions and the MC group used 3 (95% CI: 2.67–3.37) sessions to complete the task. The GEE test revealed no significant difference between the groups for the following variables (falls: χ^2=0.198, p=0.656; imbalance: χ^2=2.230, p=0.155; body control: χ^2=2.383, p=0.123; correct paddling: χ^2=2.531, p=0.112; board control: χ^2=0.077, p=0.792; task: χ^2=0.342, p=0.559) (Figure 3).

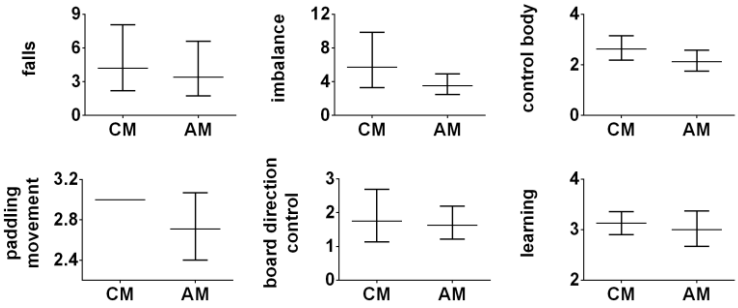

Fig. 3 Mean and confidence interval values (95%) of the number of falls, imbalance and training sessions necessary to correctly perform body control, padding movement, board direction control and completion of the task of both groups

Learning and retention tasks

In learning task performance, the CM group required 160.88 (95% CI: 149.17-173.51) seconds to complete the turn clockwise and 156.25 (95% CI: 144, 52-168.93) seconds to turn counterclockwise, bringing a total of 317.13 (95% CI: 293.97-342.11) seconds. In this same variable, the AM group required 165.89 (95% CI: 145.47-189.17) seconds to complete the clockwise turn and 165.29 (95% CI: 145.76-187, 44) seconds the counterclockwise turn, totaling 331.18 (95% CI: 292.81-374.58) seconds.

In the retention task, the CM group spent 130.73 (95% CI: 120.97-141.27) seconds to perform the turn clockwise and 121 (95% CI: 112.26-132.58) seconds counterclockwise. Considering the total time, the CM group showed 252.73 (95% CI: 233.43-273.62) seconds. Meanwhile, the AM group scored 134.92 (95% CI: 119.90-151.81) seconds for the clockwise turn and 131.65 (95% CI: 117.97-146.92) for the counterclockwise turn, totaling 266.57 (95% CI: 238.05-298.51) seconds.

The GEE test showed significant differences between tasks (learning x retention, χ^2=51.317, p<0.001). However, no significant difference was found between groups (χ^2=0.204, p=0.652). We also observed no interaction (groups*tasks; χ^2<0.001; p=0.988) in the time spent to perform the clockwise turn. Therefore, independently of the group, for each second spent in the tasks, the clockwise turn in learning task was 0.208 seconds longer than in the retention task (95% CI: 0.130-0.285, p<0.001). The same effect was observed in the time spent performing the counterclockwise turn (group: χ^2=0.960, p=0.327, task: χ^2=74.893, p<0.001, interaction: χ^2=0.132, p=0.717) and (group: χ^2=0.518, p=0.472, task: χ^2=70.187, p<0.001, interaction: χ^2=0.035, p=0.851). In this context, regardless of the group, for each second of activity, the time spent to complete the counterclockwise turn in the learning task increased 0.247 seconds when compared to the retention task (95% CI: 0.169-0.326, p<0.001). In the total time, the learning task increased 0.388 seconds for every second of activity when compared to the time spent on the retention task (95% CI: 0.151-0.303, p<0.001) (Figure 4).

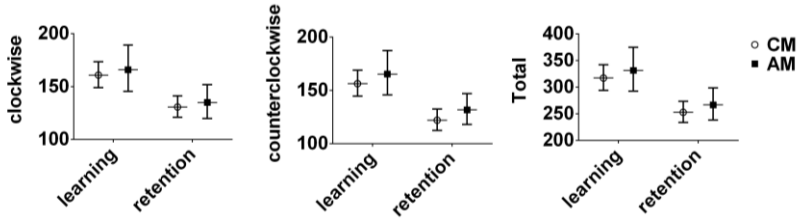

Fig. 4 Time in seconds required by both groups to perform the learning and retention tasks

DISCUSSION

Although prior studies reported that different factors such as the environment, admeasurement and materials affect motor performance (Horak et al., 1990; Brunetti, 2008; Magill, 2011; Ruess et al., 2013a; Houglum & Bertoti, 2014), in our study it was observed that the usage of a board made of recyclable materials did not impact the time spent learning SUP boarding, the number of falls and unbalances nor in the amount of training required to complete a trajectory by performing adequate movements of the SUP.

Considering the general time spent to learn the task, we observed that all participants learned it over a short period of training (3 sessions) independently of the type of material of the board used during the protocol training. Probably, this short time achieved for learning SUP boarding is associated with the early stage of motor skills acquisition, when the improvement of motor development is expressive (Walker et al., 2003). Moreover, during the first session of training, participants of both groups reported the same difficulties, including maintenance of the balance, tremor, pain and muscle fatigue in lower limbs. However, in the second session the participants conveyed no muscular discomfort and they were able to maintain the balance more easily on the board. These physical improvements can occur due to neuromuscular adaptation induced by the motor learning process (Horlings, van Engelen, Allum, & Bloem, 2008; D'Elia, 2013; Behrens, Mau-Moeller, Wassermann, Bader, & Bruhn, 2015). Neuromuscular adaptations are characteristics of the assimilation processes and learning accommodation that involves perception and body adjustments (Teixeira, 2006; Leonardi, Galatti, Paes, & Seoane, 2014). Moreover, the exercise-induced neuroplasticity can be observed in the early hours of the first training session (Toni, Krams, Turner, & Passingham, 1998; Ungerleider, Doyon, & Karni, 2002; Floyer-Lea, 2005).

When analyzing motor performance, we also noticed that the number of falls and the difficulty to maintain balance on the board were similar for participants of both groups. Furthermore, no differences were found between groups on the time spent completing both the learning and retention tasks. Although several studies reported that materials with different characteristics can impact motor performance (Horak et al., 1990; Brunetti, 2008; Magill, 2011; Ruess et al., 2013b; Houglum & Bertoti, 2014), here, we observed that the plastic made board was as effective as the resin board to provide motor learning. In this view, the little density found between them may not have been enough to interfere in the learning time and balance. However, further studies are required in order to investigate the influence of the density of a SUP board on motor learning.

Surprisingly, we noticed that both groups were able to perform the task in the retention test in a shorter time than in the learning test. This decrease was observed in the time spent to return to both sides (right and left) and in the total time, indicating that both groups learned SUP boarding effectively. The time reduction found in the retention test may be associated to the process of motor learning that is implicated in the improvement stages, including cognition, assimilation and movement automation (Teixeira, 2006; Magill, 2011), i.e., the period that participants performed without training SUP boarding may have been induced neurophysiological adaptations that allowed a better performance on the retention test. Curiously, still in the retention task, the group that used the conventional SUP boarding performed the route back to the left than to the right side. We believe that this outcome might be associated to sensory-motor and neurological mechanisms. That is because the motor performance is directly connected to motor coordination that involves capturing and sending stimuli conducted through afferent and efferent neural structures (Horlings et al., 2008). In addition, the lateral asymmetry in motor performance may be related to asymmetric brain development. However, motor asymmetry does not present a universal standard (Grafton, Hazeltine, & Ivry, 2002; Garry, Kamen, & Nordstrom, 2004; Teixeira, 2006; Bond, Cook, Swartz, & Laroche, 2017), which may justify the fact that the group that used the alternative board did not present any difference in the time spent performing the turns to both the right and left sides.

Our outcomes suggest an important alternative to the SUP boarding practice, since we found that we can produce an effective SUP board using recyclable materials such as plastic bottles. Besides the benefits that it may generate for nature, producing this type of board might facilitate the access to this sport due to the low production cost observed in our study. Furthermore, even our results showed that learning is not impacted by the type of material, further studies should assay the adaptability of the skill applying a transfer test by exchanging the boards between groups in order to provide all the information implicated in motor learning (Teixeira, 2006). We would also like to emphasize that our investigation was conducted in a swimming pool of a college where no nature variation occurs; however, SUP practicing is generally performed in nature such as the sea and rivers, where natural events may affect the SUP boarding performance and the structure of the board. Based on this, additional studies should assess environmental adaptability by conducting a transfer test in natural environments.

CONCLUSION

Here, we observed that the fact of using an alternative board did not affect the learning and practice of SUP boarding. Based on this, it can be concluded that using a board made of plastic bottles is a functional, economic, and environmentally friendly alternative to practice SUP boarding on calm waters and can replace the epoxy resin SUP board.

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DASKA IZRAĐENA OD PLASTIČNIH BOCA: FUNKCIONALNA, EKOLOŠKA I EKONOMSKA ALTERNATIVA ZA UČENJE SURFINGA

Glavni cilj aktuelnog istraživanja je da se utvrdi da li upotreba alternativne daske napravljene od plastičnih boca u poređenju sa konvencionalnom daskom utiče na učenje i uvežbavanje surfing (prema engl. Stand up paddle-SUP). Uzorak 16 zdravih učesnika regrutovan je radi pogodnosti (stariji M=23.5 godina, CI95%: 21.62-25.54; telesna visina M=170.13 cm, CI95%: 165.00-175.51; telesna masa M=69.63 kg; CI95%: 62.37-77.72) i nasumično svrstan u dve grupe: a) konvencionalni materijal (CM; n=8) i; b) alternativni materijal (AM; n=8). Kao kriterijum učenja, u obzir smo uzeli varijable kao što su broj padova, ravnoteža, kontrola tela, obrazac pokreta veslanja i vreme potrebno za postizanje stabilnosti na dasci. Nismo pronašli razlike između grupa ni u jednom kriterijumu. Takođe smo zapazili kako je izrada daske napravljene od plastičnih boca 20 puta jeftinija od kupovne konvencionalne daske izrađene od smole. Obzirom na sve navedeno, zapazili smo da je reciklirana daska funkcionalna kao i konvencionalna daska, ali jeftinija i manje štetna po prirodu.

Ključne reči: *alternativni materijali, surfing, fizička aktivnost, vodeni sportovi, učenje sporta*

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Research article

THE EFFECTS OF SKILL-BASED EXERCISES AND A SMALL-SIDED GAMES PROGRAM ON THE BODY COMPOSITION OF ADOLESCENTS

UDC 796.012.01

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Abstract. *The purpose of this experimental study was to determine the effects of a skill-based exercise program on the body composition of adolescents. The study was conducted on 90 participants, (age, 13±6 years), divided by gender then randomly assigned into two sub-samples: the experimental [SS1, N=39 (EG1, 19 girls and EG2, 20 boys)] and the control group [SS2, N=51 (CG1, 24 girls and CG2, 27 boys)]. Body composition parameters were assessed by a caliper (skinfold thickness) and bioelectrical impedance analyzer Omron BF511 (percentage of body fat tissue and muscle tissue). After conducting the 16-week program of skill-based exercises and small-sided games (SSG) related to volleyball, certain body composition parameters statistically significantly increased in the experimental groups (except body fat percent in girls, and body fat mass in both genders). In the experimental period, the SS2 increased in body fat tissue (both genders) and in muscle tissue (girls), while a decrease in muscle tissue was recorded among the boys. The results of this study showed no significant differences in the effects of the two programs on body composition at the multivariate level for both genders. Furthermore, at the univariate level it was noted that the students following the experimental program (SS1) had better results compared to the SS2 of students in terms of the decrease of body fat tissue, as well as the increase of muscle tissue for both genders. The obtained results indicate that the program of skill-based exercises and SSG related to volleyball is suitable for adequate intensification of PE classes and improvement of body composition parameters of elementary school students.*

Key words: *Skill-Based Exercise, Small-Sided Games, Body Composition, Physical Education, Adolescents.*

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INTRODUCTION

Daily physical activity (PA) levels have decreased and the prevalence of obesity increased in adolescents in the last 20 years. This global phenomenon is alarming for public health, as obesity has reached epidemic proportions (WHO, 2016). The low level of PA is defined as one of the many causal factors for obesity development (Hills, Andersen, & Byrne, 2011; Ekelund et al., 2012). Excess body composition parameters such as body fat in adolescents are associated with the risk of cardiovascular diseases, affecting quality of life and reducing the average life expectancy (Pate, Heath, Dowda, & Trost, 1996; Rey-López, Vicente-Rodriguez, Biosca, & Moreno, 2008; Nathan & Moran, 2008; Han, Lawlor, & Kimm, 2010; Regaieg et al., 2013; Stojanović & Branković, 2018). The main remedy for adolescent's obesity is an increase in the level of PA during leisure time but also in schools as a part of the physical education (PE) curriculum.

The PE is very important part of education because it can contribute to growth, optimal motor skills development, changes in body composition and psycho-social characteristics of individual by proposing appropriate physical activities (Fairclough & Stratton, 2004; Hardman, 2007).

Early studies investigating the quality of the PE curriculum showed that the current curriculum is ineffective in the aspect of providing the appropriate frequency, duration and intensity which could provide stimuli for anthropometric and physical fitness characteristics improvement among adolescents (Sallis et al., 1997; Stojanović, 1998; Branković, 2001; Milenković, 2002; Dragić, 2003; Koutedakis & Bouziotas, 2003; Jurg et al., 2006; Kirk, 2006; Stamatović & Šekeljić, 2006; Trost, 2006). Based on the above stated facts, PE curriculum goals and objectives cannot be accomplished at full scale, hence intensification of PE classes becomes urgent to investigate (Stojanović, Momčilović, Stojanović, & Stojanović 2019).

Determination of PE class modality and workload volume is very complex process and it hasn't been investigated to a satisfactory extent. It represents an inexhaustible source for further study in order to find more precise solutions (Pate et al., 2006).

In a review paper by Harvey & Jarrett (2014), plenty of research has tried to find better solutions for students' engagement in PE classes through the implementation of sport programs, modified games, small-sided and conditioned games using models with different approaches (e.g. game-centered approaches - GCAs) than the traditional one.

Skill-based exercises (SBE) share similarity with real competitive volleyball situations in aspect of structure and intensity of the player movement (Grgantov, 2003). This similarity provides training exercises to be closer to competitive demands and also contribute to engage preferable stimuli for the muscles that are important in specific movements during competition (Trajković, 2015). SBE provide the simulation of volleyball match movement patterns to students in such an environment they have to exercise actively under pressure and high intensity (Gabbet, 2002). The purpose of SBE is faster technique adoption, and manipulation of game or specific exercise to reach higher or to maintain appropriate workload intensity.

The concept of small-sided games (SSG) such as "mini-volleyball" is based on simplified rules of the game and reduced size of playing court in order to make game much more intense. Also by reducing the number of players on court, students are making more frequent contact with the ball ensuing easier and faster adoption of volleyball techniques (Marelić, Janković, Rešetar, & Marelić, 2000). As such, mini-volleyball makes the game

much more intense and interesting, which fully meets the needs of students for PA, motor and social development. In mini-volleyball, more precisely in the 3 vs. 3 game, in one set more average contacts with the ball and fewer errors in the game are achieved. The students achieve 27.7 ball contacts more compared to the traditional 6 vs. 6 game (Rešetar, Đurković, Marelić, & Borovina, 2008).

The aim of this study is to determine the effects of 16-week program of skill-based exercises and SSG related to volleyball on changes in body composition parameters of the experimental groups. The additional aim of this study is to determine the effects of a regular PE curriculum on the body composition parameters of the control groups during the same period.

METHODS

The sample of participants

The sample of participants were comprised of 90 seventh grade students (age: 13±6 months) of the Elementary School "Duško Radović" in Niš. The study sample involved only students who agreed voluntarily to participate in the study followed by testing program and physical exercise. Prior study, parental consents were obtained for every participant. The study protects the children's privacy by allowing for anonymity and was designed in compliance with the recommendations for clinical research of the World Medical Association Declaration of Helsinki (2013). This study was also reviewed and approved by the Ethics Committee of the Faculty of Sport and Physical Education, University of Niš. The additional inclusion criteria was that the students must be clinically healthy during testing protocol and should not be exempted from PE classes. For the final processing, only the results of the participants who participated in both measurements (initial and final) and had no more than two absences per month were included. The participants were firstly divided by gender than randomly assigned into the experimental and control subsamples:

1. The experimental subsample (SS1), consisted of the group of 19 girls (EG1, BH: 160.75 cm; BM: 55.32 kg) and of the group of 20 boys (EG2, BH: 164.28 cm; BM: 56.44 kg) and
2. The control subsample (SS2), consisted of the group of 24 girls (CG1, BH: 159.10 cm; BM: 48.04 kg) and of the group of 27 boys (CG2, BH: 166.30 cm; BM: 56.76 kg).

Anthropometric measurements and body composition

Following anthropometric assessment protocols by Norton et al. (2001) body height (BH) was measured via Martin anthropometer GPM 101 (GPM GmbH Switzerland) and values were recorded in millimeters (mm). Body mass (BM) was measured with a digital body mass scale Omron BF511 (Omron Healthcare Co, Kyoto, Japan) with an accuracy of 0.1 kg. Skinfold thickness was measured using GPM 6100 (GPM GmbH Switzerland), at the triceps, subscapular and suprailiac sites, with an accuracy of 0.2 mm according to the methodology recommended by the International Biological Program (Weiner & Lourie, 1969). A GPM caliper provides a constant pressure of 10g/mm^2. The measurement

results were evaluated 2 seconds after the grip was caught on the skin. All three sites of skinfold thickness were summed up to provide the sum of skinfolds (SUM3). Body composition components BF% and MM% were assessed using the BIA digital scale Omron BF511. The participants were requested to avoid the following procedures before body composition measurement as described by Rech, Cordeiro, Petroski, & Vasconcelos (2008): not to perform any physical exercises during 12 hours before testing, not to eat or drink anything during the four hours before the evaluation, to urinate at least 30 minutes before the evaluation, not to take any diuretics during the seven days prior to the test.

Procedures

The SS2 students attended total of 3 classes per week. Two classes of regular PE and one elective PE class (volleyball), following curriculum of the Serbian Ministry of Education (Official Gazette of the Republic of Serbia, 2006).

The SS1 students also attended total of 3 classes per week. Two classes of regular PE classes following curriculum of the Serbian Ministry of Education and an one elective PE class (volleyball) following the experimental program of SBE and SSG.

The SS1 students followed up the 16-week experimental program of SBE and SSG during elective PE class. Class was designed with classic four-part class structure, which included 3-5 minutes intensity activities such as specific volleyball warm-up, muscle-strengthening and mobility increase exercises in the function of physically introducing the students to the upcoming activities. The main part of the class included skill-based exercises with high intensity (70%-90% HRmax), and SSG (mini-volleyball) 2 vs. 2, 3 vs. 3 and 4 vs. 4.

Statistical analyses

For the assumption of normality, the Kolmogorov-Smirnov test was applied to analyze the result distribution for the initial and final measurements for both groups. Univariate analysis of variance for repeated measures (ANOVA) was applied to determine the differences between the initial and final measurements of the participants. The effect size was calculated using the partial eta squared (η^2_p), according to Keppel (1991). Effect size (ES) values are classified according to Ferguson (2009) as: no effects (NE) if $0 \leq \eta^2_p < 0.05$; small effect (SE) if $0.05 \leq \eta^2_p < 0.26$; moderate effect (ME) if $0.26 \leq \eta^2_p < 0.64$; and a large effect (LE) if $\eta^2_p \geq 0.64$. For determination of the effects of the experimental program multivariate and univariate analysis of covariance (MANCOVA/ANCOVA) were used. Level of statistical significance was set at $p \leq 0.05$. Statistical procedures and analyses were conducted using the statistical package STATISTICA 10.0 for Windows (StatSoft, Inc., Tulsa).

RESULTS

The results of the Kolmogorov-Smirnov test for the body composition parameters at the initial and final measurement of both genders in the SS1 and SS2, confirmed the assumption of normal distribution for all included variables, thus the parametric statistical analyses can be performed.

After confirmed assumption of normality and observation of descriptive statistics results across groups, further analyses were made possible by the parametric statistics. To determine the differences between the initial and final measurements, repeated measures ANOVA was carried out, as well as the MANCOVA/ANCOVA to determine the effects of the experimental program.

The results of the univariate analysis of the differences between the initial and final measurements of the EG1 of the girls (Table 1) showed that three body composition parameters have statistically significantly better results at the final measurement compared to the initial one. The difference between the measurements with a large effect was manifested in the variable MM (F=31.66; ES=0.64), while the differences with moderate effects are observed in SUM3 (F=22.30; ES=0.55) and MM% (F=21.70; ES=0.55).

Table 1 Differences between the initial and final measurements for the experimental group of the girls (EG1)

Variables	Mean		Std. Dev.		F (1;18)	ES
	In	Fin	In	Fin		
SUM3 (mm)	40.91	38.13*	13.79	12.23	22.30	0.55ME
BF% (%)	25.56	25.32	8.19	8.27	3.83	0.18SE
BF (kg)	14.94	14.88	8.05	7.83	0.37	0.02NE
MM% (%)	33.32	33.74*	2.61	2.72	21.70	0.55ME
MM (kg)	18.20	18.59*	2.95	2.81	31.66	0.64LE

Legend: Mean - arithmetic means; Std.Dev. - standard deviation; * - significant at the $p \leq 0.05$ level; In - initial measurement; Fin - final measurement; F - F test value; ES - Effect Size

The results of the univariate analysis of the differences between the initial and final measurements of the CG1 of girls (Table 2) indicate that there were statistically significant differences in BF (F=13.33; ES=0.37) and BF% (F=6.80; ES=SE) with better results at the initial measurement (less body fat), and significantly better results in MM (F=30.15; ES=0.57) at the final measurement.

Table 2 Differences between the initial and final measurements for the control group of the girls (CG1)

Variables	Mean		Std. Dev.		F (1;23)	ES
	In	Fin	In	Fin		
SUM3 (mm)	35.70	37.31	7.90	8.43	2.63	0.10SE
BF% (%)	20.69*	21.46	6.12	5.89	6.80	0.23SE
BF (kg)	10.27*	10.92	4.13	4.15	13.33	0.37ME
MM% (%)	34.85	34.67	1.79	1.79	3.13	0.12SE
MM (kg)	16.67	17.07*	2.17	2.19	30.15	0.57ME

Legend: Mean - arithmetic means; Std.Dev. - standard deviation; * - significant at the $p \leq 0.05$ level; In - initial measurement; Fin - final measurement; F - F test value; ES - Effect Size.

In the results of the univariate analysis of the differences between the initial and final measurements of the EG2 of boys (Table 3), it is observed that four of the five applied body composition variables have significantly better results at the final measurement. A significant difference between the measurements with a large effect was manifested in – SUM3 (F=36.41; ES=0.66), with a moderate effect among two variables – MM (F=15.37;

ES=0.45) and BF% (F=12.67; ES=0.40), and a difference with a small effect was observed for MM% (F=6.26; ES=0.25).

Table 3 Differences between the initial and final measurements for the experimental group of the boys (EG2)

Variables	Mean		Std. Dev.		F (1;19)	ES
	In	Fin	In	Fin		
SUM3 (mm)	40.34	34.96*	13.74	12.77	36.41	0.66 LE
BF% (%)	20.77	19.95*	7.33	7.23	12.67	0.40 ME
BF (kg)	12.03	12.08	5.37	5.68	0.14	0.01 NE
MM% (%)	37.27	37.81*	3.00	2.79	6.26	0.25 SE
MM (kg)	20.92	22.08*	3.41	3.97	15.37	0.45 ME

Legend: Mean - arithmetic means; Std.Dev. - standard deviation; * - significant at the $p \leq 0.05$ level; In - initial measurement; Fin - final measurement; F - F test value; ES - Effect Size

The differences between the initial and final measurement for the CG2 of boys (Table 4), showed the presence of significant differences in three body composition parameters with a better results at the initial measurement – BF (F=9.01; ES=0.26), MM% (F=7.93; ES=0.23), and BF% (F=4.62; ES=0.26).

Table 4 Differences between the initial and final measurements for the control group of the boys (CG2)

Variables	Mean		Std. Dev.		F (1;26)	ES
	In	Fin	In	Fin		
SUM3 (mm)	33.02	33.93	9.17	11.08	0.76	0.03 NE
BF% (%)	15.77*	16.33	6.26	5.67	4.62	0.15 SE
BF (kg)	8.97*	9.52	4.09	4.15	9.01	0.26 ME
MM% (%)	39.41*	39.05	2.54	2.52	7.93	0.23 SE
MM (kg)	22.41	22.55	4.65	4.65	1.26	0.05 SE

Legend: Mean - arithmetic means; Std.Dev. - standard deviation; * - significant at the $p \leq 0.05$ level; In - initial measurement; Fin - final measurement; F - F test value; ES - Effect Size

A multivariate analysis of covariance of the applied body composition variables between the EG1 and CG1 of girls at the final measurement with controlling for initial measurement (covariate) is shown in Table 5. After the analysis, it can be stated that a statistically significant difference among the groups at the required level of Q<.05 was found (Q=0.002). It is evident that the experimental program of SBE and SSG at the multivariate level had a greater effect on body composition than the regular school PE program.

Further analyses at the univariate level, (Table 5), reveal statistically significant differences in muscle mass percent (MM%: F=11.98, p=0.001), sum of three skinfolds (SUM3: F=9.21, p=0.004), body fat mass (BF: F=5.76, p=0.022) as well as in body fat percent (BF%: F=5.25, p=0.028), where the EG1 of girls achieved better results. Muscle mass – MM, did not show a statistically significant difference between the groups, but it is evident that the EG of girls achieved greater progress than the CG1 of girls at the numerical level.

Table 5 The effects of the EG1 and CG1 programs on body composition among girls (MANCOVA/ANCOVA)

Variables	Adj. Mean EG	Adj. Mean CG	$F^2(1; 36)$	p
SUM3 (mm)	35.67*	39.77	9.21	0.004*
BF% (%)	22.93*	23.85	5.25	0.028*
BF (kg)	12.60*	13.19	5.76	0.022*
MM% (%)	34.49*	33.92	11.98	0.001*
MM (kg)	17.84	17.81	0.12	0.735
Wilks Lambda	F^1	Effect - df	Error - df	Q
0.567	4.89	5	32	0.002*

Legend: Adjusted means - adjusted values of the arithmetic means; F^2 - value of the F-test coefficient; * - statistical significance; Wilks lambda - value of the Wilk's test coefficient for group centroid equality; F^1 - value of the F-test coefficient for the significance of Wilk' lambda; Effect df; Error df - degrees of freedom; Q - centroid difference significance.

Table 6 shows that there is statistically significant difference between the groups of boys at the multivariate level. The experimental program of SBE and SSG had greater effects on the body composition parameters than the school PE program among boys at the multivariate level (Q=0.005), while at the univariate level, statistically significant differences were observed in the sum of three skinfolds (SUM3: F=13.92, p=0.001), muscle mass percent (MM%: F=10.27, p=0.003), muscle mass (MM: F=7.19, p=0.011) and body fat percent (BF%: F=6.44, p=0.015), where the boys of the EG2 achieved better results than those of the CG2. It is evident that the boys from the EG2 made greater progress than the boys of the CG2, while no statistical significance was observed in body fat mass - BF.

Table 6 The effects of the EG and CG programs on body composition among boys (MANCOVA/ANCOVA)

Variables	Adj. Mean EG	Adj. Mean CG	$F^2(1; 40)$	p
SUM3 (mm)	31.70*	37.19	13.92	0.001*
BF% (%)	17.68*	18.61	6.44	0.015*
BF (kg)	10.61	10.99	2.16	0.149
MM% (%)	38.77*	38.08	10.27	0.003*
MM (kg)	22.66*	21.97	7.19	0.011*
Wilks Lambda	F^1	Effect - df	Error - df	Q
0.639	4.07	5	36	0.005*

Legend: Adjusted means - adjusted values of the arithmetic means; F^2 - value of the F-test coefficient; * - statistical significance; Wilks lambda - value of the Wilk's test coefficient for group centroid equality; F^1 - value of the F-test coefficient for the significance of Wilk' lambda; Effect df; Error df - degrees of freedom; Q - centroid difference significance.

DISCUSSION

The aim of this study was to determine the effects of the SBE and SSG program on the body composition parameters of groups of adolescents. The additional aim of this study was to determine the effects of the regular PE curriculum on the body composition parameters of the CG.

The results of the present study showed that 13±6 year-old elementary school students who participated in the SBE and SSG program (SS1) over a 16-week period showed a decrease of skinfold thickness (both genders) and body fat tissue (boys), and an increase of muscle tissue (both genders). Furthermore, the results showed that the students who participate in the regular PE curriculum (SS2) over the same period, have increased body fat tissue (both genders) and muscle tissue (girls), while a decrease in muscle tissue was recorded among the boys.

After controling for the results from initial measurement, an analysis of covariance showed significant differences between the effects of the two programs, with more favourable changes in body composition parameters such as skinfold thickness, body fat tissue, and muscle tissue in the SS1 than in the SS2, similar for both genders. The most favourable changes with large effects occurred in the SUM3 variable which represents the sum of three truncal skinfold thickness values (triceps, subscapular and suprailiac). While body fat percent is a good indicator of the total amount of adipose tissue in the body, anthropometric measures of truncal skinfolds are good indicators of the distribution of subcutaneous adipose tissue in the central region which is known to be related with health risks (Deurenberg, Pieters, & Hautvast, 1990; Snijder, Van Dam, Visser, & Seidell, 2005; Pereira et al., 2015).

This outcome of the SS2 in both genders was expected, considering that many previous studies characterize the regular PE curriculum as ineffective in terms of appropriate frequency, duration and intensity (Milenković, 2002; Koutedakis & Bouziotas, 2003; Jurg et al., 2006; Kirk, 2006; Trost, 2006). In the research by Zegnal-Koretić (2017), the author stated that there is a prevalence of overweight children, who are in the pre-obesity and obesity phase, with a transition to higher grades. The author states that in the fifth grade about 13% of overweight children (8% pre-obese; 4.9% obese) were recorded, while in the 8th grade 20% of overweight adolescents (14% pre-obese; 5.8% obese) were registered. The above facts indicate that the current PE curriculum fails to meet the needs of students, especially in a period of rapid growth and development, where engagement in PA is very important for proper musculoskeletal development and body fat reduction.

The results obtained on the effectiveness of the implemented the SBE and SSG program are in accordance with the previous studies evaluating specially designed sport-based programs as a part of the curriculum, or as extracurricular activities (sports class, sport specific training, etc.). Volleyball drills and skills combined with physical conditioning increase the intensity of volleyball-specific training and as such can contribute to increased muscle mass percent for a short period of 4 weeks among young female volleyball players (Stojanović, Bešić, Stojanović, Lilić, & Zadražnik, 2018). In a study by Ljubojević, Višnjić, & Ilić (2012), content related to basketball showed positive effects on the morphological characteristics in boys, to a smaller extent, and in girls, to a greater extent. Results from studies that evaluated programs in the form of SSG related to soccer, with intensity above 70% HRmax, showed that soccer games with reduced numbers of players (3 vs. 3) compared with a higher number of players (5 vs. 5) achieved a greater amount of engagement (frequent

contact with the ball) and higher heart rates (Owen, Twist, & Ford, 2004). Also, SSG related to soccer showed a body fat reduction in boys, after a period of 11-12 weeks (Carrasco, Reigal, Ulloa, Chirosa, & Chirosa, 2015; Milanović, Pantelić, Kostić, Trajković, & Sporiš, 2015), but after a shorter period of 8 weeks showed no significant effects on body composition parameters (Hammami et al., 2018). Different exercise programs, but still with an intensity above 70% HRmax, also achieved a reduction in skinfold thickness (Lazaar et al., 2007; Farias et al., 2009), body fat tissue (Regaieg et al., 2013) and an increase in muscle tissue (Lazaar et al., 2007; Farias et al., 2009; Regaieg et al., 2013) among adolescents.

Recorded progress in the SS1 among girls and boys in terms of body composition parameters can be attributed to the applied experimental treatment, but it should be taken into consideration that the students were in the period of an adolescent growth spurt, where the occurrence of accelerated growth and development is present, especially in anthropometric characteristics such as body height and body mass, as well as changes in certain parameters of body composition, depending on biological maturity and gender. One of the indicators of biological maturity is Peak Height Velocity (PHV) and represents the maximum growth rate during accelerated development in adolescence (Mirwald, Baxter-Jones, Bailey, & Beunen, 2002). The maximum growth rate in adolescence begins between the ages of 12 and 14 for both sexes (Viru et al., 1999; Mirwald et al., 2002).

Girls and boys in young adolescence have approximately the same values of the body mass index (BMI) until the seventh grade, when a dramatic decrease occurs among boys, due to accelerated body height gain Zegnal-Koretić (2017). BMI values in this study were used only to specify the characteristics of the sample, and were not monitored during an experimental period regarding serious limitations of BMI as an index of adiposity in children (Garn, Leonard, & Hawthorne, 1986).

Comparing the results of cross-sectional studies, Malina (2004) stated that muscle tissue growth of girls and boys is nearly linear around puberty, with slightly higher values among boys, where increment in muscle tissue is associated with the growth hormone, and from puberty with testosterone. Hormonal changes during puberty lead to an increase in adipose tissue in girls and lean body mass in both sexes (Siervogel et al., 2003). Adipose tissue increases to a much greater extent in girls because body fat represents an essential energy deposit, which is required for the normal functioning of female gonads (Phillips, Bandini, Compton, Naumova, & Must, 2003). After the age of 11, the amount of adipose tissue in boys decreases, while in girls it increases (Viru et al., 1999; Schwandt, von Eckardstein, & Haas, 2012). In boys, the level of androgens is higher than the level of estrogen leading to masculinization, and in girls, the level of estrogen is higher than the level of androgens, so feminization occurs (Pinel, 2010).

Based on the above mentioned changes in parameters of body composition during adolescence, it can be concluded that students were at specific stage of development followed bv facts that hormonal changes, along with accelerated growth, development, and puberty occurs in middle school age (11-15 years).

The experimental program of the SBE and SSG caused changes in the parameters of body composition among the girls with respect to the reduction of adipose tissue during maturation when, from a biological point of view, the accumulation of body fat is an essential deposit of energy required for full sexual maturation. The experimental program also contributed to the increase in muscle tissue in girls and boys, as well as the reduction of adipose tissue in boys, which is consistent with the growth hormone most prevalent

during adolescence, especially in boys. For these reasons, some biological factors that affect changes in body composition during adolescence are very important to monitor, in order to properly plan and program PE classes to meet the needs of students, as well as their motor and biopsychosocial development.

CONCLUSION

From the obtained results from this research, it can be concluded that the experimental program of skill-based exercises and small-sided games, designed with increased intensity of the elective PE class (volleyball), contributed to significant changes in the body composition parameters, more precisely, a reduction in skinfold thickness and total body fat, and muscle mass increment of elementary school students. Obtained information clearly indicates that experimental program have the greater effectiveness and superiority comparing the current PE curriculum effects.

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EFEKTI PROGRAMA SITUACIONIH VEŽBI I IGARA NA SKRAĆENOM PROSTORU NA TELESNU KOMPOZICIJU UČENIKA

Sa ciljem da se utvrde efekti programa situacionih vežbi i igara na skraćenom prostoru na telesnu kompoziciju učenika, sprovedeno je istraživanje na 90 ispitanika, prosečne starosti 13 godina koji su podeljeni po polu, a zatim slučajnim izborom svrstani u dva subuzorka: eksperimentalni [SS1; N=39 (CG1, 19 devojčica i CG2, 20 dečaka)] i kontrolni subuzorak [SS2; N=51 (CG1, 24 devojčica i CG2, 27 dečaka)]. Parametri telesne kompozicije su procenjeni kaliperom (debljina kožnih nabora) i metodom bioelektrične impedance, tj., uređajem Omron BF511 (procenat masnog i mišićnog tkiva). Nakon primene 16-to nedeljnog programa situacionih vežbi i igara na skraćenom prostoru iz odbojke, svi parametri telesne kompozicije značajno su se poboljšali kod EG (osim procenta masnog tkiva kod devojčica, i mase masnog tkiva kod oba pola). U eksperimentalnom periodu ispitanici SS2 su zabeležili značajne promene u telesnoj kompoziciji u vidu povećanja masnog tkiva (kod oba pola), smanjenja mišićnog tkiva kod dečaka i povećanje kod devojčica. Rezultati ovog istraživanja pokazali su da je bilo značajnih razlika između efekata dvaju programa na telesnu kompoziciju na multivarijantnom nivou, zatim je na univarijantnom nivou uočeno da ispitanici SS1 nakon primene eksperimentalnog programa imaju znatno bolje rezultate u odnosu na ispitanike SS2 u parametrima telesne kompozicije u vidu smanjenja kožnih nabora, masnog tkiva i povećanja mišićnog tkiva kod oba pola. Dobijeni rezultati ukazuju da je ovakav eksperimentalni program pogodan za intenzifikaciju nastave fizičkog vaspitanja i pozitivne promene u telesnoj kompoziciji učenika osnovnih škola.

Ključne reči: *telesna kompozicija, situacione vežbe, igre na skraćenom prostoru, fizičko vaspitanje, učenici.*

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Research article

PHYSICAL ACTIVITY OF ADULTS DURING GREEK TRADITIONAL DANCE AND TENNIS SESSIONS

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Abstract. *Physical Activity (PA) is connected with many health benefits and leads to a better quality of life. However, the modern way of life imposes such high levels of sedentary behaviours that physical inactivity is among the key risk factors for mortality. People's participation in active recreational and/or exercise programmes that increase the levels of PA seems imperative if their health is to be enhanced. The aim of this study was to examine the potential differences between the PA offered by Greek Traditional Dance (GTD) and Tennis to adult participants. One hundred and two adults, aged 20 to 76 years, members of GTD (n=57) and Tennis (n=45) clubs, volunteered to participate in the study. The PA gathered during GTD or Tennis was recorded during two randomly selected sessions with Omron 720 pedometers. A multivariate analysis of variance (MANOVA) was computed on the participants' total steps (TS) and aerobic steps (AS). Statistically significant differences were found between GTD and Tennis in TS ($F_{1,100}$=35.18, p<.001, η^2=.26) in favour of GTD, but not in AS ($F_{1,100}$=.87, p=.35, η^2=.009). It can be concluded that GTD sessions offer higher levels of ambulatory activity than Tennis. However, taking into account both the recommendations of daily PA for adults (≥10.000 steps/day) and the finding of previous studies reporting PA accumulated during various recreational/sport activities, it appears that both GTD and Tennis can significantly help people achieve satisfactory PA levels.*

Key words: *Recreational Activity, Pedometers, Health*

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INTRODUCTION

It is well known that regular participation in Physical Activity (PA) offers several health benefits, including muscular and cardiorespiratory fitness improvement; bone and functional health enhancement; stress and depression reduction, and significantly contributes to the improvement of the quality of life (Word Health Organization-WHO, 2019). According to WHO (2010), a healthy adult aged 18 to 64 years old is considered as physically active, only if he/she manages to accumulate 150 minutes of moderate-intensity PA throughout the week, or 75 minutes of vigorous intensity throughout the week, or a combination of them. Trying to find ways to motivate people to be physically active, researchers translated the aforementioned PA guidelines into steps/day equivalents, since pedometers are inexpensive motion sensors that can be easily used to assess PA (Tudor-Locke & Bassett, 2004, Cvejić, Buišić, Mitrović, & Ostojić, 2019). Thus, an individual is thought of as physically active when he/she accumulates 10000 steps or more per day, whereas those who take more than 12000 steps/day are characterized as "highly active" (Tudor-Locke & Bassett, 2004).

On the contrary, physical inactivity is strongly connected to noncommunicable diseases and obesity (International Society for Physical Activity and Health, 2017; WHO, 2018), constituting a leading risk factors for death (WHO, 2018). People who are insufficiently active have a 20% to 30% increased mortality risk compared to sufficiently active people (WHO, 2018). Some years ago, WHO member states, taking into account the fatal negative consequences of physical inactivity on people's health and quality of life, committed to a 10% reduction of insufficient PA by 2025 (WHO, 2013). Nevertheless, it seems that no progress in achieving the above goal has happened so far (Guthold, Stevens, Riley & Bull, 2018). The high percentage (27.5%) of people worldwide being inactive that was revealed in a recent study (Guthold et al., 2018) can be attributed to several sedentary behaviors that prevail in several aspects of daily life, like occupation; transport; leisure time. Greece is a country with a high prevalence of both physical inactivity (30.0%-39.9% for men and 40.0%-49.9% for women; Guthold et al., 2018) and obesity (in people older than 16, overweight=43.4% and obese=11.6%; Hellenic Statistical Authority, 2018).

It seems imperative that both global and national policies aiming at enhancing people's active transportation and participation in free or organized PA should be implemented if public health is to be safeguarded. Considering organized PA, several researchers maintain recreational exercise programmes, like aerobic gymnastics (Chatzigianni, Monastiridi, Katartzi, & Arabatzi, 2017; Rangan et al., 2011), basketball (Lynch, Corbin, & Sidman, 2009), resistance exercise (Rangan et al., 2011), and dance (Argiriadou et al., 2013a) can significantly contribute to the increase of total daily PA. In this sense, the assessment of the amount of PA that different active recreational activities offer to participants would provide valuable information in order for those activities to be evaluated as a means of PA promotion. In Greece, two of the most popular active recreational activities are Greek traditional dance (GTD) and Tennis, with several participants in a wide age range (Argirou & Spinos, 2017).

The aim of the present study was to examine the potential differences between the PA offered by GTD and Tennis to adult participants.

METHODS

Participants

One hundred and two adults (51 men, 51 women) aged 20-76 volunteered to participate in the study. Among them, 57 (23 men, 34 women) took part in Greek Traditional Dance (GTD) sessions and 45 (28 men, 17 women) in Tennis sessions organized by respective clubs in Athens, Greece, one or two times per week. All of them had at least one year of experience. Before their participation in the study, all the aforementioned adults were informed in detail about the aim and the procedures of the study, and provided their written consent.

Instruments

Walking Style Pro HJ-720IT-E2 Omron pedometers were used to record ambulatory activity during GTD and Tennis sessions. This model records steps when placed vertically, horizontally or upside down, due to its piezoelectric sensors that use multi-position measurement technology, and has been found to accurately record adults' ambulatory activity (Giannakidou et al., 2012). According to their manual, Omron 720 pedometers can provide information about the (a) steps taken, (b) distance, (c) time, (d) calories and (e) fat volume during walking or jogging. Regarding steps, Omron 720 pedometers give information about the total count of steps (TS) taken and also aerobic steps (AS, counted when walking more than 60 steps/minute and more than 10 minutes successively). In the present study both TS and AS were used.

Demographic characteristics

The demographics of participants were collected through a questionnaire, which consisted of items gathering information about the (a) age, (b) gender, (c) years of participation in GTD or tennis, and (d) years of participation in sports or recreational activities.

Procedures

First, an informative meeting was held in tennis and dance clubs, in which the first author informed the club members about the purpose and the procedure of the study, and guaranteed that their participation would be anonymous and voluntary. At the end of this meeting, written consent forms for participation were given to the club members, who had to fill them out and sign them. One week after the first meeting, the authors visited each club again two times in order to record PA during two 60-min randomly selected sessions. Each participant was given a pedometer five minutes before the beginning of the session and wore it on his/her right hip; at the end of the session, the pedometers were removed. Moreover, at the end of the first measurement, the participants filled out a demographic questionnaire. No instructions had been given to the teachers/coaches about the content of their session.

Statistical Analysis

First, the average ambulatory activity of each participant during two GTD and tennis sessions recorded were computed. At a preliminary level, potential differences between the ambulatory activity of males and females within each activity group were investigated, using a t-test. Since no statistically significant differences were detected, the males' and females' data were merged. Then, a multivariate analysis of variance (MANOVA) was computed on the participants' TS and AS to investigate the potential difference between tennis and GTD in the ambulatory activity gathered. Statistical analyses were performed with the use of the IBM SPSS Statistics 25.0 and the alpha level was set at 0.05.

RESULTS

Table 1 provides descriptive statistics aggregated by gender and recreational activity, for age and ambulatory activity. The t-test performed on average steps of men and women separately for GTD and Tennis, showed that there is no statistically significant association between the participants' gender and their ambulatory activity either during a GTD (t=1.55, p=.13) or a Tennis session (t=.43, p=.67).

Table 1 Descriptive statistics for age, total steps, and aerobic steps

	Greek traditional dance		Tennis	
	Males (n=23)	Females (n=34)	Males (n=28)	Females (n=17)
Age	42.96 ± 13.82	39.82 ± 14.38	43.96 ± 11.43	38.53 ± 7.75
Total step counts	4094 ± 612	4309 ± 433	3463 ± 753	3558 ± 657
Aerobic steps	773 ± 259	1145 ± 263	844 ± 302	773 ± 235

The MANOVA that was applied on the participants' total and aerobic steps revealed that the multivariate results were significant for the recreational activity group (Pillai's trace=.29, F=19.83, p<.001, η^2=.29). Subsequent univariate analyses indicated that there were statistically significant differences between Tennis and GTD in the total steps ($F_{1,100}$=35.18, p <.001, η^2=.26), with GTD having higher scores than Tennis, but not in aerobic ones ($F_{1,100}$ =.87, p=.35, η^2=.009).

DISCUSSION

Participation in active recreational and exercise programmes are thought to contribute to the enhancement of PA levels (Lynch et al., 2009; Rangan et al., 2011; Argiriadou et al., 2013a; Chatzigianni et al., 2017) and promote health and quality of life (WHO, 2018). Evidence suggests that step-based metrics used in accordance to the federal PA guidelines facilitate individuals' ability to comprehend and achieve a physically active lifestyle (Tudor-Locke & Aguiar, 2019). The aim of this study was to examine the ambulatory activity gathered by adults who participate in GTD and Tennis programmes.

The results showed that the participants in 60-min GTD sessions accumulated on average 4222 steps, whereas those who participated in 60-min Tennis sessions presented statistically significantly lower average step counts (3499 steps). This may be due to the fact that in GTD, the participants should execute specific movements that each dance consists of, whereas in a Tennis session each participant decides on his/her own how active he/she will be (covering a small or a big part of the court). Regarding AS, the differences between the two activities were statistically insignificant, although participants in GTD gathered more AS than those who took part in Tennis. A possible explanation for that finding is that a GTD session may contain both fast and slow dances. Thus, during a session with a higher percent of slow dances, the frequency of steps taken would not be sufficient enough in order for those steps to be recorded as AS. The step counts of the GTD sessions in this study were slightly lower than that revealed (4721 steps) in the study of Argiriadou and colleagues (2013a), in which a GTD session of the same duration took place. However, lower PA was recorded in a previous study, in which a 30-min continuous walking (3411 steps/session) and a 70-min exercise programme, consisting of resistance and aerobic exercise (3729 steps/session), were implemented (Tudor-Locke, Jones, Myers, Paterson, & Ecclestone, 2002). It seems that GTD, although not a sport activity, offers higher PA levels than other programmes. This finding, in conjunction with those of previous studies showing that GTD also contributes to the participants' quality of life (Argiriadou et al., 2013b; Bougiesi, Zisi, Gregoriou, & Pollatou, 2011), and supports that GTD can be treated as a valuable PA.

In the present study, participants' daily step counts were not measured; thus, it was not possible to examine PA differences between days with and without GTD or Tennis. Nevertheless, in previous studies the daily ambulatory activity of people aged 31 to 65 (8408 steps; Lynch et al., 2009) or older than 60 = [6480 steps (Tudor-Locke et al., 2002); 6250 steps (Hernandes et al., 2013)], when they did not participate in PA programmes, has been found to be lower than recommended. Moreover, several researchers have shown that more PA is accumulated on days including an organized PA programme than on those without (Tudor- Locke et al., 2002; Lynch et al., 2009), refuting in that way the PA compensation concept, according to which a decrease in PA follows increased PA (Lynch et al., 2009). From the above mentioned, it can be assumed that both GTD and recreational Tennis can significantly contribute to the achievement of the 10000 steps/day recommendation (Tudor-Locke et al., 2004).

The results of this study should be interpreted in the prism of its limitations that require discussion. To begin with, the relatively small sample size does not allow for result generalization. Moreover, as it was earlier reported, only the ambulatory activity gathered during GTD and Tennis sessions was measured and not that of the rest day; thus, a clear picture of the participants' total daily activity on days with and without GTD or Tennis has not been obtained. Furthermore, although the pedometers provide information about steps taken when walking more than 60 steps/min and more than 10 minutes successively and called them aerobic, this information is not sufficient enough for describing activity intensity. Nevertheless, despite its limitations, this study adds information for the PA offered through two popular recreational activities and shows that they both contribute to the PA enhancement. However, undoubtedly, further research is needed if sound conclusions are to be drawn. Studies examining PA gathered in a variety of recreational activities could provide valuable information that will help people select the best activity for them.

CONCLUSION

GTD sessions seem to offer higher ambulatory activity than Tennis sessions; however, both recreational activities provide their participants with a valuable amount of PA. Although, as it has already been mentioned, further research is needed to obtain sound conclusions about the contribution of each recreational/sport activity to public health, participation in active recreational or exercise programmes should be encouraged and promoted if physical inactivity of people today is to be reduced.

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FIZIČKA AKTIVNOST ODRASLIH TOKOM GRČKOG TRADICIONALNOG PLESA I TENISA

Fizička aktivnost (FA) ima zdravstvene prednosti i vodi ka boljem kvalitetu života. Međutim, savremeni način života nameće visok nivo sedentarnog ponašanja da je fizička neaktivnost među ključnim faktorima rizika smrtnosti. Učešće ljudi u aktivnim programima za rekreaciju i/ili vežbanje koji povećava nivo FA čini se imperativom u poboljšanju zdravlja. Cilj ovog istraživanja bio je da se ispitaju potencijalne razlike između FA koje odraslim učesnicima nude Grčki tradicionalni ples (GTD) i Tenis. Stotine dve odrasle osobe, starosti od 20 do 76 godina, članovi GTD (n=57) i teniskih (n=45) klubova, dobrovoljno su učestvovali u istraživanju. FA tokom GTD-a i Tenisa utvrđena je Omron 720 pedometrima tokom dve nasumično odabrane sesije. Multivarijantna analiza varijance (MANOVA) izračunata je na ukupnim koracima učesnika (TS) i aerobnim koracima (AS). Statistički značajne razlike utvrđene su između GTD-a i tenisa u TS-u (F1,100=35.18, p<.001, ē2=.26) u korist GTD-a, ali ne i u AS-u (F1,100=.87, p =.35, ē2=.009). Zaključuje se da GTD nudi veći nivo ambulantne aktivnosti od tenisa. Međutim, uzimajući u obzir i preporuke dnevne FA za odrasle (>10.000 koraka/dan) i nalaz prethodnih istraživanja o FA prikupljenih tokom različitih rekreativnih/sportskih aktivnosti, čini se da i GTD i tenis mogu značajno da pomognu ljudima da postignu zadovoljavajući nivo FA.

Ključne reči: *rektreativna aktivnost, pedometri, zdravlje*

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Professional article

THE ROLE OF THE TEACHER IN THE APPLICATION OF INCLUSIVE TEACHING OF THE SUBJECT NATURE AND SOCIETY IN REGULAR CLASSES

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Abstract. *The main aim of this paper is to point out the specifics of teachers' work in teaching the subject Nature and Society, using different forms of teaching, learning and assessment, which ensure equal access to education for all children in accordance with developmental and personal educational affinities, and age. The paper focuses on a teachers' need for education, expertise, knowledge and the skills necessary for inclusive teaching of the subject Nature and Society in regular classes with students with disabilities. The importance of the teachers' role in the teaching process with students with disabilities has been emphasized, in relation to their integration and inclusion into normal life. The success of an education system is reflected in attracting, and choosing the right candidates, capable people for work in the classroom, which contributes to greater and better student achievement.*

Key words: *Inclusion, Integration, Teacher, Student.*

INTRODUCTION

Inclusion in the education of students in the elementary grades and their integration into regular classes is an indispensable issue of the modern educational system, understood as a process which would ensure quality education for all students, respecting their various needs, abilities and expectations. It also carries with it certain challenges for society, schools and social participation.

The most important assumption in the education of students with disabilities is that teachers are trained to work in regular schools, under inclusive conditions. Initial education

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and continuous professional development of teachers play a key role in developing positive attitudes towards inclusion, as well as developing knowledge and skills that are necessary for the work in an inclusive environment (Forlin, 2013).

In educational work, the people who make the changes most often are teachers, because they are a key factor in the successful implementation of inclusive education in the school as a basic factor of educational work. Teachers are expected to be experts both in the subject they teach and in the field of teaching in general. In order to accomplish this, they have to continually improve their own knowledge and reflect on their own practice (Momčilović & Momčilović, 2016). Their acceptance of inclusion in the field of education is the promotion of inclusive values and is focused on the creation and implementation of teaching units in the curriculum.

The term inclusion implies the process of involving students with disabilities into regular work programs, with an emphasis on the individualization of students with disabilities and their mutual integration. All students have equal development opportunities and chances of success, and they participate actively in teaching activities, creating a positive environment based on tolerance and respect.

The term integration is associated with a number of unresolved problems, of which the most significant is the lack of support for the full integration of students with disabilities in regular classes. The difference between these two concepts refers to the difference between belonging to the inclusive and fitting in the integrated process. Inclusion implies a change in circumstances in regular schools for the purpose of customization of students with disabilities, or to create such an atmosphere in which every student, regardless of the type of interference, would feel comfortable and able to develop in every way.

Bearing in mind that inclusive education has only recently become a topic in our country, the question arises: How do teachers fulfill their professional obligations?

It is crucial that the teacher is capable of quality implementation of educational practice. Ilić (2009) gives great attention to the dimension of inclusive education, and speaks about the inevitability of the professional competence of educational workers - teachers, as well as their methods and methodological skills. Methodological skills are linked to identifying the individual's differential learning disparity, while the methods are linked to developing and implementing programs and models of individual interactive and joint learning in inclusive teaching.

The main aim of this paper is to point out the specifics of teachers' work in the teaching of the subject Nature and Society, using different forms of teaching, learning and assessment, which ensure equal access to education for all children in accordance with developmental and personal educational affinities and age.

The role of teachers in integrating students with disabilities into regular classes

The success of the education system is reflected in attracting, and choosing the right candidates, people capable of teaching, which contributes to the higher and better achievements of students. This is achieved by selecting people with a high level of linguistic, mathematical and general educational literacy, possessing strong interpersonal and communication skills, a great will for learning and motivation for teaching. Increasing teacher knowledge in strategies and knowledge of both inclusion and mainstreaming can assist teachers in feeling better prepared to work with students with disabilities (Alfaro, Kupczynski & Mundy, 2015).

Teachers are the main factor in educational work, and represent a key factor for the successful implementation of inclusive education in school. Their professional development is a necessary driver for schools, and their acquisition of knowledge and skills enables them to be good teachers and educators. Teachers have the power to improve, develop, and make the difficulties acceptable, using didactic-methodical procedures. Together with their abilities and possibilities, they can create a positive atmosphere, which ultimately aims to socialize students. Effective teachers display a wide range of skills and abilities that lead to creating a good learning environment. Knowledge of content must be balanced with a solid grounding in effective teaching strategies (Amusan, 2016).

The role of teachers, which refers to the integration of students with disabilities in regular classes, is extensive and recognized in theory. The concepts of integration and inclusion differ: integration implies simply transferring children with developmental disabilities from special schools to regular schools, while inclusion, as a concept that is put before schools and society, demands certain changes be made in order to adjust the school environment to students with disabilities. It is where the importance of the teachers' role emerges.

As seen in the literature, the role of teachers is one of the most important factors for the functional implementation of social inclusion. The professional standard for teachers, which makes demands on the personal qualities of a teacher is developed: the readiness to teach all children regardless of their inclinations, abilities, disabilities, limited opportunities (Fahrutdinova, Yarmakeev, & Fahrutdinov, 2016). Cox (1993, according to Gilligan, 1998, p. 572) states that school factors that promote positive behavior and good adaptation of children with disabilities include "high expectations for work and behavior, teachers as good models of behavior, respect for children and their ability to achieve, so that children could be included in school, clear disciplinary rules, encouraging good behavior and careful use of punishment, pleasant working conditions, a good teacher-student relationship, and a coherent support structure for teachers". The relationship with the teacher in many ways affects the child's academic, cognitive and social development and adaptation. The teacher is a motivator and the creator of future relationships of joint activities, which would facilitate understanding between them, and thus contribute to the development of students. Good relationships between teachers and students are characterized by a high level of closeness and low level of conflict, which contributes to a positive affect and open communication, lack of difficulty in managing the behavior of the child. Their good relations create an atmosphere of support and emotional security in which students feel confident and supported. According to Pianta (1999) "in these conditions, children are better able to organize and manage their emotions, engage in effective interactions with others, confidently explore resources of classrooms and departments, involve in class activities and focus on learning".

Teachers are expected to adjust their work to students with disabilities and the dynamics of the group that is changed significantly when classes are attended by students with disabilities, depending on the type of disability. A teacher's competencies are very important for the implementation of inclusive education and are embedded in the competencies related to the professional abilities of teacher, where they are most prominent: the teacher's belief that all students can learn; respecting students as individuals; respecting the dignity of students; perseverance in helping all students achieve success; as well as respect for diversity.

A teacher's pedagogical skills are characterized by the management of the classroom, personal responsibility for the progress of each student, the motivation of students to act

in a way that meets their personal needs and the needs of the classroom. The teacher works to reduce obstacles in working with students, possesses mediation skills for solving problems, promotes a positive relationship between students, engages students for individual and competent teaching activities, and supports the development of common values, interaction, academic discussion, individual and group responsibility in order to create a positive climate and respect in the department. A teacher possesses pedagogical knowledge for inclusive education. It is necessary to include knowledge, abilities and skills, in order to review and understand the educational process, which should be adapted to inclusive conditions. Teachers possess psychological skills, which include the knowledge and ability of his adapting to students with disabilities, monitoring their progress and identifying the difficulties that students have in the learning process. Their methodical skills are reflected in the planning and preparation of the class and the use of all methods, learning techniques, the use of educational didactic means, a modern approach to teaching, skills of including students in the teaching process, and the development of critical thinking.

Preparing teachers for inclusive teaching

With a change in the role of teachers and students, newer and harder demands are placed before the teacher, where the teacher is assigned a central role in developing the idea of schools for all, the idea of guiding for individualization and inclusion in education. The development of inclusion gives the teacher a central role, and therefore the need for education in accordance with the requirements of inclusion, at the level of general and professional development. If a teacher wants to be successful, s/he needs to keep up with modern times, because as the students change, their needs change too, and so do the inevitable and professional changes of the teachers who are dealing with them. Teachers are forced to innovate their practice, and lifelong learning is a common denominator of various forms of learning in order to improve the teacher's competence. It is necessary that teachers, being informed about modern tendencies in education, acquire new knowledge, read professional literature, and attend seminars in accordance with their needs. Given the change in student population needs, the skills and competencies of general education teachers must be buttressed to meet the diverse needs of diverse students (Shaffer & Thomas-Brown, 2015).

The educational system of future teachers must ensure the equal right and access to education and upbringing, and the acquisition of knowledge through various forms of teaching and learning. In addition to knowledge and skills, an integral part of teacher competencies are value attitudes that are not subject to assessment in higher education institutions that educate future pedagogical workers.

The Bologna way of studying and adapting higher education has led to the introduction of new subjects at the faculties of Teacher Training, Sport and Physical Education and pedagogical faculties, in order to acquire knowledge for working with students with disabilities, and to the possibility of specializing in elective subjects for work specialists. Colleges, including the Teacher Education Faculty in Belgrade, University of Belgrade and the Pedagogical Faculty in Vranje, University of Niš, introduced a mandatory course into their programs - Methods on Working with Children with Disabilities, while at the Faculty of Education in Jagodina, University of Kragujevac gaining knowledge in this field is represented in the subject Methods of Special Work with Mildly Disturbed Students. At the

Faculty of Sport and Physical Education, University of Niš there are mandatory courses - Adaptive Physical Exercise and Sports for Individuals with a Physical Disability (Jorgić et al., 2014), while the course - Sports for Individuals with a Physical Disability is an elective one at the Faculty of Sport and Physical Education, University of Belgrade.

It is well known that a school is worth as much as the sum value of the teachers who work in it. Although teachers have acquired the knowledge and skills necessary for the development of the average student during his studies, in order to perform the task and to participate in the education and upbringing of students with disabilities, they need to improve constantly. Teacher education requires links to all educational structures, and Darling and Hamond (2006) point out that the field of teacher training must inevitably continue to develop away from the academic environment towards a closer connection to schools on the ground and their common plan to change, with all the potential problems that can be encountered. Hoban and Hoban (2004) believe that such a plan must be based on four aspects: conceptual links between university curricula; the connection between theory and practice in the school and university environment; social and cultural links between participants in the program. They conclude that the social and cultural dimension is one that includes the other three, emphasizing that the social interaction between participants is the one that enables the program to be dynamic and modifiable according to the relevant cultural and political needs, whereby communication is at the heart of a coherent educational program for teachers. Inclusion is, among other things, life without prejudice.

The European Agency for Human Rights (2010) prepared a teacher profile that covers the following areas of knowledge, experience and skills: evaluating students' idiosyncrasies; support for all students; working with others, and personal professional development. Teachers are not just lecturers, but organizers who have to devise new ways of working with students and to have control in the classroom. An inclusive teacher uses the approach of learning, at center of which is the student. Such an approach is characterized by respect for each student, and working with him as a person. A teacher understands diversity among students and does not use students' characteristics to categorize and label them. In order for a teacher to become inclusive, s/he must go through the transformation of identities and basic theses that are managed in practical teaching.

Teacher education should include a comprehension of differences that may be related to culture, language, family, pre-education, differences in the developmental level of intelligence, a preferred learning style, or specific learning difficulties. Teachers need to recognize the importance of understanding motivation, possessing certain types of learning knowledge, and having the skills to use a wide range of techniques to evaluate / assess student knowledge. They need to gain knowledge on the management strategies of education, according to the different styles, they should know the resources of curriculum and technology, have knowledge of cooperation with students, parents and other educators, and to be qualified for analysis of their own work in order to evaluate the effects of their knowledge.

The professional development of future teachers, educators and professional associates, has the goal of acquiring knowledge and skills for working with students with disabilities. Although the Rulebook on Continuing Professional Development prescribes the necessity of attending the program in the form of a hundred hours of realization and professional development of teachers, educators and professional associates, the data indicates an insufficient number of professional development programs.

Basic characteristics of the inclusive teaching of the subject Nature and Society in regular classes

The areas of inclusive education are being upgraded every day, taking their own place in the regular teaching process through all subjects of elementary school education. An elementary school teacher has to synthesize methodological knowledge of individual disciplines into a single unit. This provision serves as a prerequisite for the allocation of the methodological sphere of the professional activity of teachers working in elementary grades (Akhmedova, 2019). Physical activity (walking, discovering nature, etc.) are an integral part of the inclusive approach to teaching. Studies show that as many students with disabilities as possible should be included in regular classes. The possibilities of involving these students in the curriculum of the subject Nature and Society are big and they oblige teachers to improve and acquire knowledge and skills to work with these students.

There is a huge difference between the individual involvement of students with disabilities in regular classes and the inclusion of students in the education system with students with no developmental disabilities. It is therefore important that teachers of all subjects, including the subject Nature and Society, prepare to work with students with disabilities, especially when it comes to classes spent in nature.

In regular classes, to work with students with disabilities, teaching contents, methods of work and work programs for the classes of the subject Nature and Society, must be adapted to them, so that students with disabilities would not feel uncomfortable, and their (motor, psychic, emotional) characteristics would develop in the right way. The contents that teachers adapt to these students in the subject Nature and Society should enable students with disabilities to feel socially accepted, useful, satisfied, happy, and fulfilled. During these classes, students develop and improve motor skills, strengthen their body, gain experience, safety and self-confidence, a sense of acceptance from their peers, a sense of community and cooperation with other students. If the curriculum is not a tailor-made curriculum that suits them, students with disabilities can feel discriminated and discarded, and hence, because the activities are not in accordance with their abilities, they will not be able to participate in the teaching process in a quality manner.

The relationship between teachers and students with disabilities regarding the subject Nature and Society will depend on a number of factors, including social engagement, learning outcomes and necessary support. For many students with disabilities, the classes of the subject Nature and Society are not a positive experience, especially when it comes to classes spent in nature. Students encounter difficulties: relationships with peers, marginalization and lack of interaction with teachers (Blinde & McCallister, 1998).

Strugs, Mastropier and McDuffie (2007), emphasize that joint teaching is a strategy to reduce the gap between regular and special education, as well as that teaching practice includes actions between special and regular teachers which are dealing with relevant issues in the classroom. A number of authors have questioned the acquisition of motor skills and changing attitudes among inclusive and non-inclusive teaching in the classes of the subject Nature and Society for students with disabilities, and they came to the conclusion that improvements in attitudes towards inclusion were found in classrooms supported by teachers.

Work with these students enables teachers to share their knowledge and expertise within the class, with students of different abilities, with the application of greater joint flexibility and responsibility. Within a regular process of upbringing and education, an expert teacher, using new teaching strategies and modification of curricula, tends to

improve the teaching process, in order to achieve an equal, comprehensive participation of students during teaching. Teachers in regular classes tend to plan globally, and need to see the difference in teaching methods in order to meet the needs of individuals.

Teachers are dealing with effective strategies, and they do not always have the necessary knowledge to successfully involve children with disabilities in regular classes. LaMasfer, Gall, Kinchin and Siedentop (1998) identified the lack of support in adaptation, as well as the lack of general knowledge of disability, as well as factors that contribute to the inability of teachers to involve students with disabilities. Students with disabilities are in some way inferior to their peers who do not have developmental problems.

Didactic-methodical specifics of the work of teachers in the teaching of the subject Nature and Society in an inclusive class

The specificity of providing support in didactic-methodical structuring of the teaching process and learning of students with disabilities depends on the number of students and their specificity. Even teachers with years of experience in working with these students often have the fear, surprise and need for improvisation in direct contact and all from the conclusion that practical work is not sufficient, but also requires theoretical support, self-confidence, and intuition regarding their students. The ability of teachers to help students with disabilities by adjusting methods, materials and teaching tools, with the help of visual aids, characterized by striking and large letters, documentary or film material, graphic representations, models or practical didactic aids, is necessary. For teaching the subject Nature and Society, the most appropriate methods are multi visual methods, which contribute to the engagement of students in a comprehensive way, with the use of accompanying materials in the form of paintings, posters, plastic materials, toys, etc. In addition to these, there are other possibilities of teaching, for example recording of the teaching process or the use of specific tools.

In this type of class, students respond to shorter sequences of work with sufficient time to repeat and understand the subject that is being processed. Also, it is useful to connect students through the application of work in pairs or groups, as a form of assistance or control of work. Here, the teacher provides students with disabilities with additional time to perform tasks, simplify working procedures, and handle less complex logical tasks. Teachers regularly monitor and motivate students in their work with an emphasis on a clear system of expectations and rules, which are often stressed for students. When assessing knowledge and giving grades, teachers evaluate, depending on the students from the regular classes involved in teaching, which method of assessment to take. In the organization of the teaching process, students need help and support, so they could make progress. In addition, the schedule of activities that will be known to them should be determined. Teachers establish certain communication rights which are clear and well known, speak in a calm and soft way, with more frequent praise of the students.

The didactic methodical process consists of a process of planning and programming based on the initial assessment of the knowledge, skills and abilities of students regarding the subject Nature and Society. The teacher, together with a pedagogue and psychologist, prepares a plan for the subject Nature and Society, and performs an assessment. With individualized programming, teachers predict the implementation of a smaller number of facts and generalizations, abstract content and principles of graduality. The teachers didactically adjust the contents of learning in a clear, understandable and simple way, and

connect them with the needs of the everyday life of students and the possibilities of their application. They separate only essential things with simplicity, while the practical tasks are chosen so that they are related and in line with textual part of the assignments. Complex tasks are explained and mastered with students by stages, respecting principles ranging from the simpler to the more complex. Students are introduced to simple practical assignments, with clear explanations, while individual student work is based on close examples.

For the purposes of self-learning, teachers indicate what is important in the text, the text contains familiar words, the sentences are short, a cognitive map plan is created, obvious support is provided using the method of demonstration, drawing and practical work in clarifying abstract and complex concepts. During the oral presentation, teachers adapt the words to the student's vocabulary, using clear and shorter sentences focused on what is important, with a certain amount of repetition and checking for the student to understand them. During oral presentations, they use conversations, by asking questions, and adjust the amount of complex content to the intellectual and reading ability of the team of students, with support if necessary. Teachers use sources from reality whenever it possible, and the teaching tools (visual, audible, textual) in a way that the student's attention is guided by observation and directed to key content (Ainscow, Booth, & Dyson, 2006). Adjustment of the means for easier teaching is based on the development of individualized visual means, free from the details that impede students in understanding the objective reality.

Teachers form the methodological organization of the text with sentences, copying the text in parts, selectively dictating with a sufficient number of repetitions, at a reasonable pace and clarity. The principles of inclusive work should not be contradictory to the general principles of educational work, on the basis of the emotional atmosphere and the sense of security that should be provided to students. Teachers base their educational work on individualization, the student's skills of identification, use of specific and specially adapted didactic material in learning and exercising, while respecting the principles of gradualness.

The progress of students in teaching is planned in well-defined procedures, at a pace that students can follow. Assisting students with disabilities implies that a teacher applies learning methods that will ensure the use of acquired knowledge in new situations.

Teachers adjust didactic supplies and materials, images, applications and other educational instruments to the abilities of students to stimulate their socialization and learning. The forms of work that teachers apply are the same as in the course of regular work, with group work and interactive teaching, work in pairs, a workshop approach and individually tailored tasks. All of the students participate in group work, regardless of their abilities, social background or social status. Teachers encourage students to learn one from another, in order to respect the individual needs of the students based on democratic participation. In groups, students have the opportunity to choose, develop critical thinking and accomplishments, and to work with different sources, with which they are trained for responsibility and mutual help.

It should be noted that inclusion does not require a specific methodology, but harmonization of existing methods and forms of work. Research has shown that teachers who have developed pedagogical tact, understanding and a sense of working with children can do it successfully (Ainscow, Booth, & Dyson, 2006). Teachers know the lawfulness of the development and the needs of students, so that with regular observation, monitoring and evaluation of students' progress, they have the ability to individualize the educational goals of students. Successful inclusive teachers respect and accept individual differences among students, but they strive to acquire knowledge and skills to work with students with

disabilities through professional development and practical experience of direct work. These teachers base their work on expert assessments of the students, their possibilities, interests and needs, and adjust the forms, methods and content of their work.

CONCLUSION

The school, as one of the foundations of a single socio-educational system, is exposed and follows the trends of social changes. Inclusive education represents one of the fundamental human rights today. Inclusion in education means including the students with disabilities in regular schools in order to ensure the quality education and development of each student under the same conditions. Comprehensive student preparedness for inclusive education is a necessary requirement for the successful implementation of inclusive policy and practice. In addition to a number of roles of modern education, a teacher has a special place and role in it as a leader, a mediator in the learning process.

Today, teachers are not sufficiently prepared to work with students with disabilities, because regular education does not provide enough opportunities for the development of knowledge and skills necessary for work in an inclusive environment. First of all, it is necessary to work on future teachers' development of positive attitudes toward inclusion, as well as their encouragement for the planning and realization of the teaching process that meets the needs of all students. In addition to teachers as one of the most important factors of inclusive education, it is necessary to determine what is needed for the content of education that relates to inclusive practice, to include experts of different backgrounds, to compile the opinions of workers who are involved in working with children with disabilities. Also, the preparation of future teachers to work in an inclusive classroom is not enough if everything is reduced to the study of theoretical learning in inclusion, and not on the acquisition of appropriate skills for work in inclusive departments.

The teaching of the subject Nature and Society in an unique way contributes to the learning, personal development and health of students and promotes broad competence and knowledge of activities, growth and development, understanding of the importance of a healthy lifestyle, self-esteem in the context of physical activity (hours spent in nature, hiking, mountain climbing), interpersonal skills, as well as lifelong interest and engagement in activities.

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UČITELJ I SPECIFIČNOSTI NJEGOVOG RADA NA IZVOĐENJU INKLUZIVNE NASTAVE IZ PREDMETA PRIRODE I DRUŠTVA U REDOVNIM ODELJENJIMA

Cilj rada je da se ukaže na specifičnosti rada učitelja u nastavi prirode i društva, primenom različitih oblika nastave, učenja i ocenjivanja, što obezbeđuje jednako pravo i dostupnost obrazovanju i vaspitanju za svu decu, a u skladu sa razvojnim, ličnim obrazovnim i starosnim afinitetima. Rad se bavi potrebom učitelja za obrazovanjem, stručnošću, posedovanjem znanja i sposobnostima za izvođenje inkluzivne nastave kroz predmet prirode i društva u redovnim odeljenjima sa učenicima sa posebnim potrebama. Istaknut je značaj uloge učitelja u nastavnom procesu sa učenicima sa posebnim potrebama, u odnosu na njihovu integraciju i inkluziju i normalan život. Uspešnost jednog obrazovnog sistema ogleda u privlačenju i u odabiru pravih kandidata, sposobnih ljudi za rad u nastavi, koji će doprineti većim i boljim postignućima učenika.

Ključne reči: *inkluzija, integracija, učitelj, učenik*

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Research article

PERCEIVED EXERTION AND MODERATE TO VIGOROUS PHYSICAL ACTIVITY IN MIDDLE SCHOOL STUDENTS ACCORDING TO THE PHYSICAL EDUCATION TEACHERS' EXPERIENCE

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Abstract. *The aim of the current study is to compare the perceived exertion and moderate to vigorous physical activity (PA) among first grade middle school students in physical education (PE) classes given by PE teachers with higher or lower experience than 16 years. Eighty-seven PE lessons conducted by PE teachers with ≥ 16 years of experience (n=35) and teachers with < 16 years of experience (n=52) were evaluated by 348 middle school students (Mean age=12.2±0.5 years). To determine the perceived exertion, the pictorial children's effort rating table (PCERT) was completed, after PE. Children chose an option on an illustrated scale 1–10 perceived exertion. The moderate to vigorous physical activity (MVPA) was evaluated using the System for Observing Fitness and Instruction Time (SOFIT) assessing the intensity as the proportion of time that students spent engaged in walking and very active PA during PE. A cross-sectional design was used, the equality of variance was calculated using the Student t-test for independent samples resulting in MVPA (P-value=.659) and perceived exertion (P-value=.205) α≤ than 0.05. In both groups, the average value of perceived exertion was less than 5 points on the scale, which is insufficient to enhance physical fitness. The MVPA did not achieve international guidelines of engaging students in at least 50% of the lessons time in walking and very active PA. It is recommended for PE teachers to develop pedagogical strategies contributing from the school environment to guide students in educational contents for health through PA, as established by UNESCO and recommended by the World Health Organization*.

Key words: *Physical Education, Middle School, Perceived Exertion, Teaching Experience*

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INTRODUCTION

Quality education is part of the sustainable development goals established by the United Nations Organization (UN) for the reduction of extreme poverty in several dimensions (Pérez Betancourt & Betancourt Rodríguez, 2019). Quality education and investment in health through physical education (PE) area were established by the United Nations Educational, Scientific and Cultural Organization (UNESCO), in its guide for policy makers who work around PE (McLennan & Thompson, 2015; Frizzo & Silva Souza, 2019). Meta-analysis and systematic review papers suggest that children and adolescents engaged in regular physical activity (PA) are associated with lower risk of chronic diseases such as obesity (Cvejić, Pejić, & Ostojić, 2013; Brooke, Corder, Atkin, & van Sluijs, 2014; Sims, Scarborough, & Foster, 2015).

The World Health Organization (WHO) recommends accumulating at least 60 minutes of moderate to vigorous physical activity (MVPA) daily (WHO, 2014). In Mexico, the national health survey reports a percentage of physically active girls and boys of 17.2% and 21.8% respectively, in schoolchildren aged from 10 to 14 (ENSANUT NM 2016). PE conducted in schools has been highlighted as an educational area to reach most young people to promote a healthy active lifestyle (Kim, 2012; Lonsdale et al., 2013; Langford et al., 2015).

As a conceptual framework in our study, intensity is determined based on energy expenditure and physical effort versus some sort of resistance, thus causing more strain on the body within a specific period of time (Borg, Hassmen, & Lagerstrom, 1987, Veal & Campagnone, 1999; Li, 2006; McKenzie & Van der Mars, 2015). Perceived exertion is related to PA and refers mainly to muscular work that implies tension mostly of the musculoskeletal, cardiovascular, and pulmonary systems; along with motivational and emotional aspects (Borg, 1982).

PE professors should invest all pedagogical and physical effort activities to engage students in pleasurable and fun activities that will induce them to taking part in extra school PA (Shilton, 2008). Additionally, the international guidelines established by the National Association for Sport and Physical Education (NASPE) outlined that students should engage in moderate-to-vigorous PA in at least 50% of the PE lesson, with activities of energy expenditure similar to walking or running (Banville, 2006; NASPE, 2009).

Research conducted in Mexican elementary schools assessing MVPA in PE lessons using the System for Observing Fitness and Instruction Time (SOFIT) as an instrument (McKenzie, Sallis, & Nader, 1992), show MVPA in less than 50% of students (Hall-López, Ochoa-Martínez, Zuñiga, Monreal, & Sáenz-López, 2017; Hall-López, Ochoa-Martínez, Macías, Zuñiga, & Sáenz-López, 2018).

In Mexico, the Secretariat of Public Education (SEP for its abbreviation in Spanish) establish PE as part of the mandatory curriculum and students must participate twice a week for 50 minutes per lesson. This model promotes a pedagogical intervention which leads children towards lifelong PA (SEP, 2017).

According to the SEP (2017) teacher experience refers to the years worked as a teacher in the basic education system in Mexico. Teacher experience suggests that environment within which PE lessons are delivered can greatly affect MVPA (Brooke et al., 2014; Hollis et al., 2016).

Studies correlate the fact that the higher the teacher experience of PE teachers, the higher the intensity of the PE classes (Chow, McKenzie, & Louie, 2008; Lonsdale et al., 2013; Sutherland et al., 2016).

Therefore, it is hypothesized that more experienced teachers conduct more intensive PE lessons, and the aim of the current study is to compare the perceived exertion and MVPA among first grade middle school students in PE classes given by teachers with experience higher or lower than 16 years.

METHODS

Participants

This research was approved and founded by the Autonomous University of Baja California, protocol number 149/2/C/5/21. The study design was a cross-sectional baseline with a non-probabilistic convenience sample (Thomas, Nelson, & Silverman, 2015). Data were collected through August and December 2019, and PE teachers were evaluated from public middle schools located in the urban area of Mexicali Baja California, Mexico. The study followed the ethical principles regarding human experimentation proposed by the Helsinki declaration (Puri, Suresh, Gogtay, & Thatte, 2009).

Eighty-seven PE lessons conducted by 87 teachers were divided into two groups: the first group (n=35) consisted of PE teachers with ≥ 16 years of experience (an average of 22.7±3.6 years ranging from 16 to 33 years of working in the Secretariat of Public Education) and the second group (n=52) consisted of PE teachers with < 16 years of experience (an average of 12.7±2.9 years ranging from 1 to 15 years of working in the Secretariat of Public Education). Lessons were evaluated by 348 first grade middle school students (Mean age±SD=12.2±0.5 years).

We set as a cutoff point of 16 years of experience because the retirement age among men is 32 years of teacher service and among women 30 years.

Procedures

Perceived exertion was determined by means of the Pictorial Children's Effort Rating Table (PCERT) developed by Yelling, Lamb and Swaine (2002) based on Borg's CR-10 scale (Borg, 1982). Adjusting it to the cognitive development of the children, figures have been added to the scale, making it more appropriate to choose the option of a representative value for the age of the children. The scores ranged from 1 to 10 with a median value corresponding to 5. This instrument is translated and validated into Spanish and the application of the scale was performed immediately for the four same PE students evaluated by SOFIT after the PE class was finished, and in the same facilities of the elementary school (Hernández-Alvarez, del-Campo-Vecino, Martínez-de-Haro, & Moya-Morales, 2010).

In order to determine the MVPA during PE lessons, the System for Observing Fitness Instruction Time (SOFIT) was used. SOFIT is an objective tool for assessing the quality of PE instruction that provides a measure of student activity levels and has been calibrated using heart rate monitors and validated using accelerometers, and used in many PE studies (Mckenzie et al., 2002; McKenzie & van der Mars, 2015). Six data collectors were trained following the standard of the SOFIT protocol, memorizing operational definitions of codes and learning tactical procedures.

Reliability measures were taken in 100% of the PE lessons observations (Kappa statistics 0.87). Interpretation of Kappa was according to the following scale: excellent 1.00–0.81; good 0.80–0.61; moderate 0.61–0.40; weak 0.40–0.21; and absence of agreement 0.20–0, when compared to the trained observers and the chance of agreement in relation to the reference data collector according to Szklo and Nieto (2007).

Using the procedures outlined in the SOFIT manual, onset of the PE lessons, trained observers randomly selected 4 students (2 boys and 2 girls). Observers recorded MVPA using a time-sampling system of 10-seconds of observing and 10-seconds of recording intervals while being paced by audio prompts from mp3 player. The coded intensity of PA was scored as 1=lying down; 2=sitting; 3=standing; 4=walking; 5=very active. To identify moderate-to-vigorous PA the codes 4=walking and 5=very active were combined as the proportion of time.

Statistical analysis

The data analysis was performed using the Statistical Package for Social Sciences (SPSS) version 23.0 for Windows (IBM Corporation, New York, USA), by calculating the descriptive values of the variables. In order to verify the normality of the groups and the data variables, the Kolmogorov-Smirnov test was used (degree of significance P-value ≥ 0.05). In order to compare fixed variables of two groups of teachers with different years of experience, with the numerical random variables being perceived exertion and MVPA, parametric statistics were used: the Student t-test for independent samples. Significance was set at $\alpha \leq 0.05$, i.e. 5% as a percentage of error of the statistical test.

RESULTS

Descriptive statistics of 87 PE lessons assessed by SOFIT in middle school students can be seen in Table 1.

Table 1 Descriptive statistics for the sample (n=87)

Variables	Mean* ±	SD	Mean** ±	SD
Lying Down (%)	4.1 ±	1.3	3.9 ±	1.2
Sitting (%)	17.6 ±	4.3	16.7 ±	3.7
Standing (%)	41.7 ±	13.3	42.6 ±	11.2
Walking (%)	23.9 ±	9.5	25.2 ±	11.1
Very Active (%)	12.7 ±	3.1	11.6 ±	4.7

* Conducted by teachers with ≥ 16 years of experience (n=35 measurements);
** conducted by teachers with < 16 years of experience (n=52 measurements); SD – Standard Deviation.

The perceived exertion of students who participated in PE classes taught by PE teachers with more than 16 years of practice had a value of 4.9±1.3, while in the case of PE teachers with less than 16 years of practice this value was 4.7±1.6.

Percentage expression of the PE class duration in minutes in the 35 PE classes taught by PE teachers with more than 16 years of experience was 36.6±5.1 % (range 22-49) and in the 52 PE classes of PE teachers with less than 16 years of experience was 36.8±5.0 % (range 28-51).

The Kolmogorov-Smirnov test resulted in a P value ≥0.05, indicating normality of groups and variance homogeneity of the data [resulting in perceived exertion (.376) and MVPA (.659) in classes taught by PE teachers with more than 16 years of experience and perceived exertion (.205) and MVPA (.172) in classes taught by PE teachers with less than 16 years of experience]. Variance between the mean and standard deviation (SD) of the variables studied in PE classes taught by PE teachers according to years of experience was calculated using the Student t-test for independent samples. This resulted in a significance level of P higher than 0.05 α≤ in perceived exertion (.562) and MVPA (.374) respectively (Figures 1 and 2).

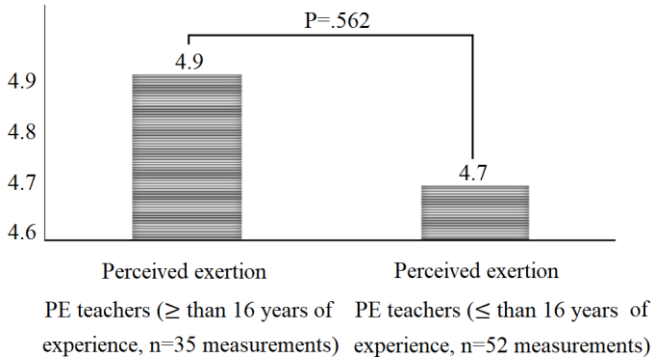

Fig. 1 Mean of Perceived exertion of middle school students in PE classes and variance between two groups

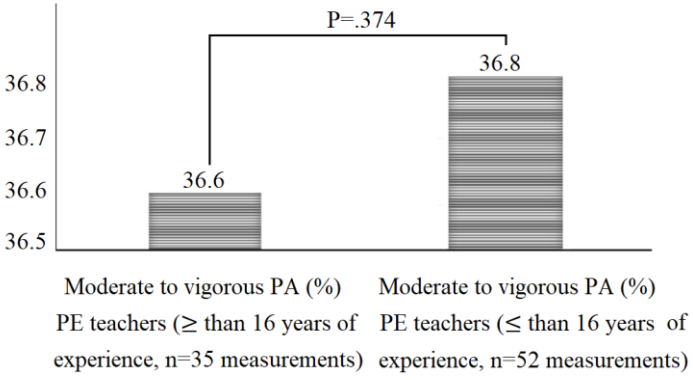

Fig. 2 Mean of % of Moderate to vigorous Physical Activity (MVPA) of middle school students in PE classes and variance between two groups

DISCUSSION

It is hypothesized that more experienced teachers conduct PE lessons with more intensity (Chow et al., 2008; Lonsdale et al., 2013; Sutherland et al., 2016).

However, the main result of this study is that the significant differences in perceived exertion and MVPA among first grade middle school children in PE classes given by teachers with years of experience lower or higher than 16 were not determined.

These values of % MVPA were similar to related studies carried out in Mexico, in a similar sociodemographic context, using the SOFIT measurement protocols for PE classes conducted in public education (Hall-López, Ochoa-Martínez, Zuñiga, Monreal, & Sáenz-López, 2017; Hall-López et al., 2018).

According to our results, neither of the two groups reached the internationally established standards set by the NASPE, recommending that PE lessons engage students in MVPA for at least 50% of the PE lesson (Banville, 2006; NASPE, 2009).

The reasons for the differences in PA participation during PE can be influenced by the environment, such as equipment, class size, teacher credentials, facilities, the scheduled lesson, length and the number of lessons provided per week (Story et al., 2009; Brooke et al., 2014; Salazar et al., 2015; Hollis, Nanney, & Schwartz, 2016).

PCERT as an alternative pedagogical assessment tool is seeking to contribute towards children's recommended level of PA and to help them understand how to self-regulate their activity (Yelling et al., 2002). In both groups within the actual study the PCERT average value was less than 5 points on the scale. It should be taken into account that values equal to or greater than 5 represent a heart rate above 150 beats per minute (Cowden & Plowman, 1999). Our result should be considered insufficient to produce the necessary adjustments for better organ function resulting from PA. The data from our study is consistent with other research involving school-age children (Hernandez et al., 2010, Hall-López et al., 2017b).

Regarding years of teacher experience, Griffey and Housner (1991) found that experienced PE teachers ask many more questions before they began planning in comparison to inexperienced PE teachers. In addition, experienced PE teachers' plans reflect a concern about contingencies that might arise during instruction, whereas inexperienced PE teachers' plans do not. Those are the reasons why student engagement shows a marked difference between experienced and inexperienced PE teachers.

Macdonald (1999) investigated whether experienced PE teachers perceive the same frustrations and negative orientations as inexperienced PE teachers. His data suggest that in many respects their working conditions and orientations are more supportive and positive than those reported for inexperienced PE teachers.

The Teacher's Behavior and the intensity of PA have reported where in PE 90.6% of time the teacher did not promote effort (Retamal-Valderrama, Delgado Floody, Espinoza-Silva, & Jerez-Mayorga, 2019). Wadsworth, Robinson, Rudisill, & Gell (2013) report that PE teachers who approach a motivational climate allow children to spend more time in MVPA compared to PE teachers who approach a performance-oriented climate. These results highlight the importance of teaching adjustment, as implement strategies, materials, and content to ensure quality in the movement related to the PE curricula (Jovanović & Minić, 2018).

It has been shown that greater time scheduled in PE does not necessarily result in more student accrual of MVPA minutes (Smith, Monnat, & Lounsbery, 2015).

Kwon, Welch, & Mason (2020), report an association of motor content in PE teacher's in-class and higher promotion of PA. Fun and interesting teaching content was significantly and inversely associated with a MVPA contribution in PE (Cvejić, Buišić, Mitrović, & Ostojić, 2018).

Additionally, appropriate work organization and contemporary inclusion of all the children into the exercise process and decrement in the loss of time during setting up the formation and explaining simpler content enhance the aerobic capacity in students, through specific tasks that will help students to improve healthy living habits (Hall-López et al., 2017; Guijarro-Romero, Mayorga-Vega, Casado-Robles, & Viciana, 2019; López-Taveras, & Moya-Mata, 2019).

Teacher training has been successful in achieving moderate PA in PE; studies with an intervention design show that a well-designed specialist targets decrement in sedentary time in PE (Rosenkranz et al., 2012; Carson et al., 2014; Telford, Olive, Cochrane, Davey, & Telford, 2016).

CONCLUSIONS

Limited by the design, our cross-sectional study prevents us from inferring causality. In addition, it was conducted on a sample of PE teachers limited to Mexicans who conduct a curriculum in a pedagogical model of competencies. Despite these limitations, the results presented here allow us to better understand potential restrictions when the PE lessons without strategies for involving the students in MVPA are concerned. The measurement instruments used in the research have a low cost and are easy to apply in large samples. They are valid and offer a non-invasive means to measure the intensity and perceived exertion in PE, as well as provide educational support for PE teachers within the context. PE teachers might find it useful to design proposals aimed at increasing the PA level among adolescents, for at least 50% of class time regardless of years of experience, respecting the recommendations for children and adolescents established by the WHO for the achievement of a minimum of 60 minutes of PA in a day of moderate to vigorous intensity. This is how quality education and investment in health through PE principles established by UNESCO should be promoted.

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OPAŽENI NAPOR I UMERENA DO SNAŽNA FIZIČKA AKTIVNOST SREDNJOŠKOLACA NA OSNOVU ISKUSTVA NASTAVNIKA FIZIČKOG VASPITANJA

Cilj istraživanja je da se uporede opaženi napor i umerena do snažna fizička aktivnost (FA) učenika prvog razreda srednjih škola na nastavi fizičkog vaspitanja koju drže nastavnici fizičkog vaspitanja sa iskustvom većim ili manjim od 16 godina. Osamdeset i sedam sati nastave fizičkog vaspitanja koje su sproveli nastavnici sa ≥16 godina iskustva (n=35) i nastavnici sa <16 godina iskustva (n=52) ocenjeni su od strane 348 srednjoškolaca (prosečne starosti 12.2±0.5 godina). Da bi se utvrdio opaženi napor, nakon nastave fizičkog vaspitanja popunjena je PCERT tabela dečjeg napora u kojoj deca biraju opciju opaženog napora na ilustrovanoj skali od 1 do 10. Umerena do snažna fizička aktivnost (MVPA) procenjena je korišćenjem Sistema za posmatranje fitnesa i vremena instrukcije (SOFIT) ocenjivanjem intenziteta kao dela vremena u odnosu na učenike koji hodaju i vrlo su fizički aktivni tokom nastave fizičkog vaspitanja. U istraživanju transferzalnog karaktera jednakost varijanse je izračunata pomoću Student t-testa za nezavisne uzorke koji su rezultirali sa MVPA (P-vrednost=.659) i opaženim naporom (P-vrednost=.205) a≤ od 0.05. U obe grupe, prosečna vrednost opaženog napora bila je manja od 5 bodova na skali, što je nedovoljno za poboljšanje fizičke spremnosti. MVPA nije ispunila međunarodne smernice o uključivanju učenika u hodanje i vrlo aktivnu fizičku aktivnost najmanje 50% nastavnog vremena. Nastavnicima fizičkog vaspitanja se preporučuje da razviju pedagoške strategije koje doprinose usmeravanju učenika prema obrazovnim sadržajima i zdravlju putem FA, u skladu sa preporukama UNESCO i Svetske zdravstvene organizacije.

Ključne reči: *fizičko vaspitanje, srednja škola, opaženi napor, nastavničko iskustvo*

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Research article

RELIGIOSITY AND PHYSICAL EDUCATION STUDENTS' ATTITUDES TOWARDS HOMOSEXUALITY

UDC 613.01

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Abstract. *The aim of the present study was to investigate the attitudes of self-oriented heterosexual students of the Department of Physical Education and Sports Science towards male and female homosexuality, in combination with the level of religiosity they display. The religiosity factor was evaluated based on the frequency of visits paid to temples to perform religious duties. Concerning their attitudes, the scale used was the Greek version of Attitudes Towards Lesbians and Gay Men (ATLG) with two factors, for male and female homosexuality respectively. The sample consisted of 552 self-oriented heterosexual students. The independent variables used were related to gender, age, and religiosity. From the analysis of the results, it was found that the factor of religiosity has a decisive influence on the formation of heterosexual students' attitudes towards both male and female homosexuality. It is further suggested to investigate the factor in combination with other variables.*

Key words: *Religion, Homonegativity, Sports*

INTRODUCTION

A particular population which is of some interest to many researchers from many fields of science is university students, especially as far as the research concerns the relationship between religiousness and attitudes towards homosexuality (Harbaugh & Lindsey, 2015; Sarac, 2015; Olson & DeSouza, 2017). The reason why this happens concerns the exploration of the ideas and behaviors of a new generation that will lead in the future, shaping new structures and systems of relationships. Students present a particular audience to explore as they display one of the most liberal subcultures, where the probability of homophobia can

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also be detected at a lower frequency and lower intensity (Herek, 2000). Several factors, including religiosity, influence the formation of attitudes of students against homosexuality (Chapman, Watkins, Zappia, Nicol, & Shields, 2012; Georgiou, Patsantaras, Kamberidou, & Fotiou, 2019).

Religion is a very important and determinant factor in socializing and shaping individuals' attitudes and behaviors, especially in matters concerning the moral regulatory framework in which each believer is obliged to make their way (Yip, 2005; Sherry, Adelman, Whilde, & Quick, 2010). The doctrine of each religion defines the specific regulatory ethical framework and system of values by which the individual judges whether something is good or bad, moral or immoral, shaping specific attitudes and behaviors regarding specific social groups (Gray, et al., 1996; Jaspers, Lubbers, & De Graaf, 2007; Jaspers, 2008; Verbakel & Jaspers, 2010). Most religions appear negatively predisposed to homosexuality with some minor variations (Yip, 2005). In view of this perspective those who are more religious than others, and therefore follow more faithfully the dogmatic part of their religion and who are exposed to the influence of moral rules and their framework as defined by their religion, also adopt religious imperatives (Van de Meerendonck & Scheepers, 2004; Siker, 2007; Andersen & Fetner, 2008; Jaspers, 2008). Conservative behaviors and attitudes of believers, and especially those who perform their religious duties more frequently, appear to be more homophobic than those who lack such a high level of religiosity (Herek & Glunt, 1993; Gray, et al., 1996; Greene & Rademan, 1997).

Religiosity is a multidimensional concept. It consists of five dimensions: the experiential, the ritualistic, the ideological, the intellectual, and the consequential and can be explained as the religious beliefs, the commitment, and the activity involving the abovementioned dimensions (Glock, 1962). Regardless of the religion, religiosity is one of the most popular investigating factors in relation to heterosexual people's attitudes towards homosexuals. It is also referred to as one of the most important predictors of heterosexual's attitudes toward homosexuals (Arndt & de Bruin, 2006; Rowatt, LaBouff, Johnson, Froese, & Tsang, 2009; Georgiou, Patsantaras, & Kamberidou, 2015). The higher the degree of religiosity, the most negative the attitudes towards homosexuality are (Arndt & de Bruin, 2006; Gelbal & Duyan, 2006; Chapman et al., 2012). The fact that the three major monotheistic religions, Christianity, Judaism, and Islam present homosexuality as a sin and a sinful act, may interpret the fact that the more traditional, conservative, and attentive to religion the faithful are, the more negative their attitudes toward homosexuality (Sakalli, 2002).

The broader accepted definition of religious fundamentalism is that of Altemeyer and Hunsberger, (1992, p. 118) who define the concept as:

> *"The belief that there is one set of religious teachings that clearly contains the fundamental, basic, intrinsic, essential, inerrant truth about humanity and deity; that this essential truth is fundamentally opposed by the forces of evil which must be vigorously fought; that this truth must be followed today according to the fundamental, unchangeable practices of the past; and that those who believe and follow these fundamental teachings have a special relationship with the deity."*

Fundamentalists show particular zeal for their faith from any moderate believer of the same religion. Both the behaviors and the attitudes of fundamentalists towards homosexuals are negative (Altemeyer, 1981, 1988; Altemeyer & Hunsberger, 1992; Kirkpatrick, 1993;

Laythe, Finkel, & Kirkpatrick, 2001; Tee & Hegarty, 2006). This certain attitude can be seen as a barrier to establishing interpersonal friendly relationships with homosexually-oriented people also in the area of university education, as the high level of religiosity leads to disapproval of the homosexual orientation, setting a barrier to the creation of friendly relations with homosexuals (Mohr & Sedlacek, 2000).

However, it is worth noting that religion, in a paradoxical way, is also a means of helping and supporting homosexuals to overcome the psychological problems that arise from it, due to the internal homonegativity they experience. Concerning the relationship between homosexuality and religion, people's religious beliefs help them to more easily overcome their psychological traumas due to the experience of intense homonegativity (Walker & Longmire-Avital, 2013).

The aim of the present study was to investigate the attitudes of the self-oriented heterosexual students of the Department of Physical Education and Sports Science towards male and female homosexuality, in combination with the level of religiosity they display.

METHODS

The participants

For the purposes of this survey, 580 questionnaires were distributed to students of all four years of the School of the Physical Education and Sport Science, of Athens, Greece. The sampling design envisaged at least 50% plus one person per year so as to generalize the results both within the years and in the total of the school. Three students refused to fill in and returned them, setting the response rate to 99.5%. Of the 577 people who participated, 300 (52%) were men and 277 (48%) were women. 27.7% (81 men and 79 women) of the participants are in the 20-year age group, 22.9% (90 men and 42 women) are aged 22-26, 18.2% (42 men and 63 women) in the age group of 19, 18% (51 men and 53 women) are in the age group of 21 years and 13.2% (36 men and 40 women) are in the age group of 18 years. More women than men of 19 years and more men than women aged 22 to 26 participated in research $\chi^2(4, n=577)=21.05$, $p<0.001$ (Table 1). From the present study 25 students self-oriented as bisexual or homosexual were excluded, and for this reason the final number of questionnaires analyzed was N=552.

Table 1 Distribution of participants by gender and age

Age	Male		Female		Total	
	f	%	*f*	%	*f*	%
18	36	12	40	14.4	76	13.2
19	42	14	63	22.7	105	18.2
20	81	27	79	28.5	160	27.7
21	51	17	53	19.1	104	18.0
22-26	90	30	42	15.2	132	22.9
Total	300	52	227	48.0	577	100.0

Note: Frequencies have been calculated for gender

Regarding sexual orientation, 95.7% (552 students) declared themselves heterosexual, 1.9% (11 people) homosexual, and 2.4% (14 students) said they were bisexual. This research concerns only heterosexual students' attitudes and for this certain reason the 25

self-oriented homosexual and bisexual students were excluded. Thus, the final sample used was 552 questionnaires.

The majority of respondents (45.5%, 137 male and 113 women) report going to church once or twice a year, 38.4% (102 male and 109 women) declare they go church several times a year and 16.2% (55 male and 34 women) declare they never go to church. More males than females declare that they never go or go 1-2 times a year to church, while more females than males report going several times a year to church $\chi 2(1, n=550)=4.89$, $p<0.05$ (Table 2).

Table 2 Distribution of participants in terms of gender and frequency of visits to church

Visit Frequency	Male		Female		Total	
	f	*%*	*f*	*%*	*f*	*%*
Never	55	18.7	34	13.3	89	16.2
1-2 times	137	46.6	113	44.1	250	45.5
Several times	102	34.7	109	42.6	213	38.4
Total	294	53.3	258	46.7	552	100.0

Note: Frequencies have been calculated for gender

Research tools

The demographic questionnaire included independent variables related to gender, age, and frequency of religious duties as an indicator of religiosity. It is worth noting that in the results of an earlier study, the frequency with which individuals go to the church and exercise their religious duties is related to the levels of religiosity (Van day Akker, Van der Ploeg, & Scheepers, 2013).

The scale Attitudes Toward Lesbian and Gay men (ATLG) of Herek (1994) was used as a research instrument for the PE students' attitudes towards the male and female homosexuality. This scale has been translated and adapted to the Greek language and Greek culture by Grigoropoulos, Papacharitou, and Moraitou (2010).

Data collection and analysis

A cover letter was attached to the questionnaire. It contained the title of the survey, a summary with its purpose, instructions to complete the questionnaire, and the time required. It also included contact details of the researcher, for any questions that might arise. It also highlighted that the participation in the survey was optional, that the participants and their answers will remain anonymous, that the responses will be used only for scientific reasons and that the participants could have access to any information concerning the survey. Statistical analysis was completed using the SPSS software version 19 (SPSS Inc., Chicago IL, USA) and included descriptive statistics with means (M) and standard deviations (SD), Simple regression analysis ANOVA and post-hoc Scheffe pairwise analysis.

RESULTS

The independent between-groups ANOVA yielded a significant effect for both male $F(2.497)=21.83$, $p<0.001$, $\eta^2=0.08$ and the female homosexuality $F(2.497)=24.67$, $p<0.001$, $\eta^2=0.09$. From the overview of Graph 1, it appears that the higher the levels of religiosity, the higher the negative attitudes towards both male and female homosexuality.

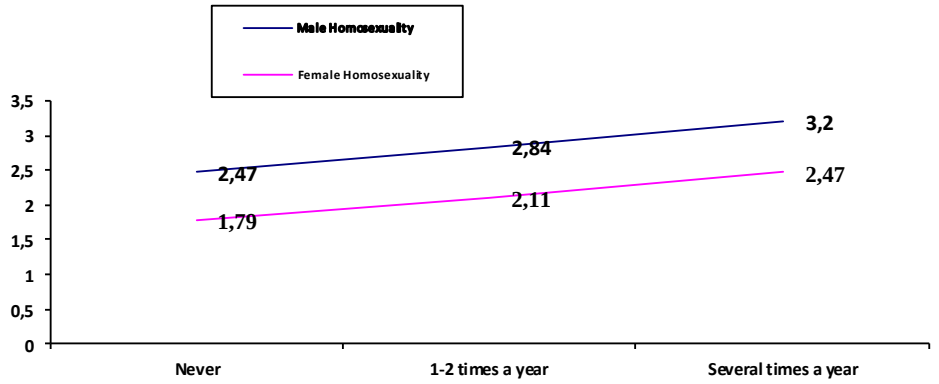

Fig. 1 Mean differences of attitudes towards homosexuality based on religiosity levels

To evaluate the differences between the different levels of religiosity, according to the visits paid per year to temples, and the attitudes towards homosexuality both for male and female homosexuality, a pairwise Scheffe Post-hoc analysis was calculated (Table 3).

Table 3 Pairwise Scheffe Post-hoc tests

Dependent variables	(I)Service Attendance	(J)Service Attendance	Mean Difference (I-J)	Std. Error	Sig. [b]
Male Homosexuality	Never	1-2 times	-.369*	.117	.002
		Several times	-.735*	.119	.000
	1-2 Times	Never	.369*	.117	.002
Female Homosexuality	Never	1-2 times	-.288*	.100	.004
		Several times	-.647*	.102	.000
	1-2 Times	Never	.288*	.100	.004

The post hoc tests results showed statistical significant differences between the "Never" and both the "1-2 times" and the "Several times" groups. There is also a statistically significant difference between the "1-2 times a year" group with the "Never" group. These results are respectively similar between groups for both the Male and Female Homosexuality.

DISCUSSION

The purpose of this research was to investigate the attitudes of self-oriented heterosexual students of the Department of Physical Education and Sports Science, of the National and Kapodistrian University of Athens, Greece, regarding male and female homosexuality and based on the different levels of religiosity they display, which manifests itself with the frequency of visiting a temple for their religious duties. Based on the results, religiousness is an important factor in attitudes towards both male and female homosexuality. The correlation of the factor with the independent variables is positive as religiosity increases, while at the same time the negative attitudes towards both male and female homosexuality increase too. The results of this research show that religiosity is an important and determinant factor associated with attitudes towards homosexuality. They also show that female homosexuality is more acceptable and participatory attitudes are

more positive, both in general and in comparison with the same levels of religiosity. These results are in line with other research findings concerning the same factor (Gelbal & Duyan, 2006; Rowatt et al., 2009; Chapman et al., 2012).

Another prospect for research concerns the deeper exploration of the factor of religiosity. As reported by Inglehart and Baker (2000), according to Max Weber, the socio-economic development of the citizens of a society significantly affect the shaping of their value system. Religious tradition and religious heritage as important socialization agents contribute significantly in shaping individual's values, choices, attitudes and behaviors (Barkan, 2006). Belief in any religious doctrine affects and creates attitudes and behaviors towards sensitive social issues, depending on the interpretation, and the perspective of the particular religion towards them. Particular reference is made to the non-discrimination of homosexuals. As long as the doctrines refers to homosexuality as a deviation and dogmas hold against homosexuality, they will negatively predefine the believers' behavior towards homosexuality and it will be negatively oriented (Gerhards, 2010).

It is also important to highlight the relationship between athletic activity and religion and, by extension, religious doctrines. For example, athletic activity in the prospects of athletic - Olympic ideology is perceived as a religious element, as a religious concept of *religio athletae*, in which the meaning and use of the human body is determined (Patsantaras, 2007). Mainly at the beginning of the 20th century, the institutionally expressed athletic action, took the character of a secularized religious substitute and acquired a symbolic meaning of interconnecting physics with the metaphysical. In view of the fact that the religious discourse is generally of an androcentric nature and since the athletic space was an androcentric social space, the conditions for the prosperity of the hegemonic mastery of masculinity, which were supported by religion, were created. As a result the androcentric characters of sport, as well as the use of the body within this specific framework, were reinforced by specific ethical values. The use of the body out of the framework given by the religious doctrines and its being adopted by sports ideology in the athletic social field is considered to a be deviation from the *normal*ity and thus unacceptable. Especially during the modernity phases and on the basis of the western cultural example, a religious character was attributed to sports activity, which, in agreement with specific Christian doctrines, emerged as a means of promoting specific moral values in western-type societies (Patsantaras, 2007). This makes sport a social space within the religious doctrine which can easily influence the perceptions of the use of the athlete's or the common trainee's body. For example, sporting activity was promoted to the global social fabric during the colonial phases in collaboration with specific Christian associations (Patsantaras, 2007). Future research should also focus the connection of religiosity with other sociocultural variables within the sport context. In this sense there are perspectives to use the sports ethical values of inclusion and non-discrimination practices to tackle the negative attitudes coming from sociological factors such are religiosity.

CONCLUSIONS

The present research has some limitations. The major one is that the results cannot and should not be generalized as the sample concerns a certain university department, that of Physical Education and Sport Science. The second one is the level of validity concerning the students' declaration of their sexual orientation. There might be an insincere sexual orientation declaration on behalf of non-heterosexual persons so as to

protect their sensitive personal data and the privacy of their life which works as a restriction. Finally, this research presented the attitudes of heterosexual students towards homosexuality. It would be interesting to search for the opinion of the non-heterosexual students, of how they are treated by their heterosexual colleagues within this specific university department, but also in the higher education institutions in general. By the time the results concerning the non-heterosexuals' opinion about the way they are being treated by their heterosexual co-students within higher education institutions, there will provide a good perspective from which to develop a strategy concerning the dissemination of free ideas, acceptance of diversity and the implementation of practices related to inclusion. All the above mentioned limitations show the path for further research in the sports science field, by adding more factors to the religiosity of the students. Further study of the relevant literature will help and guide the focus of the research.

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RELIGIOZNOST I STAVOVI STUDENATA FIZIČKOG VASPITANJA PREMA HOMOSEKSUALNOSTI

Svrha ovog istraživanja bila je ispitivanje uticaja religioznosti na stavove heteroseksualno orijentisanih studenata Departmana fizičkog vaspitanja i Sporta u Atini, Grčka, prema homoseksualno orijentisanim muškarcima i ženama u kombinaciji sa nivoom religioznosti koji iskazuju. Faktor religioznosti određen je na osnovu učestalosti poseta hramovima radi obavljanja verskih dužnosti. Što se tiče stavova, skala koja je korišćena je grčka verzija stavova prema lezbijkama i homoseksualcima (ATLG) sa dva faktora, za homoseksualnost muškaraca i žena, respektivno. Uzorak je sačinjavalo 552 heteroseksualno orijentisana učenika. Korišćene su nezavisne varijable koje se odnose na pol, starost i religioznost. Analizom rezultata utvrđeno je da faktor religioznosti ima presudni uticaj na oblikovanje stavova heteroseksualno orijentisanih učenika prema homoseksualnosti muškaraca i žena. Predlaže se dalje istraživanje faktora u kombinaciji sa drugim varijablama.

Ključne reči: *religija, negativan stav prema homoseksualnosti, sportovi*

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Research article

THE RELATIONSHIP BETWEEN SPECIFIC MOTOR SKILLS AND PERFORMANCE SUCCESS IN FOOTBALL PLAYERS

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Abstract. *The main aim of this research was to determine to which degree the system of variables used to evaluate specific motor skills correlated with the system of variables used to evaluate successful performance in football play. The study was conducted on a sample of 170 senior football players. There were 16 predictor variables to assess specific motor skills and eight criterion variables to assess successful performance. A canonical correlation analysis was applied in the statistical procedure to determine the relationships (correlations) between these spaces. Correlations were established between the investigated spaces with four pairs of canonical factors, and it has been shown that situational motor skills have high correlations with performance success in the game of football (Can R.=0.71, on average). It is indicated that the participants whose performance in football play was more successful also had better situational motor skills and that the mechanism for structuring movement is shown to be of great importance for the successful performance of tactical and technical elements in football players.*

Key words: *Situational Motor Skills, Performance Success, Football Players*

INTRODUCTION

Football is a sport game characterized by numerous complex movements (running, kicking, dribbling, jumping, or falling). The game is also distinguished by a wide variety of technical elements, tactical approaches, whole-body movements, changes in strength

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and tempo, all adding to its variability and unpredictability (Nicholas, Nuttal, & Williams 2000; Wragg, Maxwell, & Doust, 2000; Barron, 2017).

Defeating the opponent requires cooperation of all the team players, who coordinate their spatial and temporal actions with both those of the opponent and the movement of the ball. Due to the speed at which the game is played, its duration, the complexity of the movement involved, the external conditions, and the active interference of the opponent in the efforts to achieve a more favorable result, it is necessary for the player to possess a high level of motor skills (Ostojić, 2000; Mujika, Santisteban, Impellizzeri, & Castagna, 2009; Cotte & Chatard, 2011; Kokštejn, Musalek, Wolanski, Murawska-Cialowicz, & Stastny, 2019). It is estimated that during a match, 80-90% of the football players' performance is of low to moderate intensity, while the remaining 10-20% accounts for high intensity (D'ottavio & Castagna, 2001; Di Salvo, Gregson, Atkinson, Tordoff, & Drust, 2009; Carling, Le Gall, & Dupont, 2012). In the course of the match, players perform over 1000 different activities, such as breaking into an easy run from a standing position, passing the ball, or changing the direction of movement with or without the ball (Dellal, Wong, Moalla, & Chamari, 2010; Bradley et al., 2011).

Among the factors that significantly influence the success in football, situational motor skills take a special place (Bajrić, Lolić, Lolić, & Bajrić, 2009). In order to form such players in the training process, coaches use various competitive, general and specific exercises, which can be more or less effective. Situational training models that bring football players closer to the conditions of actual play on the pitch occupy a special place in the programming of the training process (Sporiš, Ružić, & Leko, 2008). Since there are position-specific differences in football players that correspond to different tasks in the game, the training program should include the specifics of the tasks for each position on the team (Javier, 2007). Football players, regardless of age, have a different level of technical and tactical knowledge (Sporiš, Jukić, Ostojić & Milanović, 2009), while the level of development of their basic and specific motor skills can serve as a criterion for directing young players to a particular position on the team (Bloomfield, Polman, & O'Donoghue, 2004, Jukić et al., 2019).

A football team functions as a particular cooperative system with 11 players acting as a personal communication network, whose modus operandi primarily depends on which team is in the possession of the ball. When a team has the ball, the main channel of communication marks the attack phase and is identified as a type of cooperative construction. The second communication network parries the first with interference and cooperative destruction, which marks the defense phase. Duel play, involving pushes, collisions, falls and blows, are typical of modern football and specifically require of a player to possess high frustration tolerance, controlled aggression, absence of anxiety, insensitivity to pain, self-dominance, stress resistance, explosive power, restraint in emotions, ability to concentrate, as well as a strong locomotor structure (Junge et al., 2000; Filaire, Lac, & Pequignot, 2003; Buchheit & Mendez-Villanueva, 2013; Buchheit et al., 2014; Kocić, Joksimović, & Stevanović, 2016).

The relationship between motor and situational motor skills in football players and the performance success in football play has not been extensively studied. Accordingly, the aim of this research was to determine to which degree the system of variables used to evaluate specific motor skills correlated with the variables used to evaluate successful performance in football play. It is hypothesized that specific motor skills have a significant correlation with success in football. The results of this study could lead to information about factors that affect performance success in football which could further contribute to the development of training technology and selection process in football.

METHODS

Participants

The study was conducted on a sample of 170 senior football players in the second and third Montenegrin football leagues (Body height=175.2±5.1 cm, Body mass=81.1±3.5 kg, age=23.4±4.3 years). All participants were healthy, rested and did not have any injuries. The participants had voluntarily agreed to participate in the research by signing an institutionally approved informed consent document. All of the testing was done in accordance with the Declaration of Helsinki.

Procedures

All situational motor tests were performed on an outdoor turf pitch, and the participants were measured by the same group of instructors, previously trained physical education teachers. The tests and the rest periods were scheduled so that the performance of a task in one test had a minimal impact on the results of any subsequent tests in order to prevent any fatigue effect.

In order to evaluate performance success, that is, the football players' efficiency, a conventional expert panel was used, comprising five judges who were licensed coaches or referees with at least five years' experience of playing for a football club. Each judge gave an independent subjective assessment of the players' performance of technical and tactical skills in the game, their level of physical fitness, engagement in attack and defense, behavior and dedication. The judges' grades ranged from 1 to 5 and were awarded in three championship matches. All tests were performed according to similar previous studies (Gabrijelić, Jerkovič, Aubreont, & Elzner, 1982).

The sample of variables

Sixteen tests were selected as the measuring instruments to assess situational motor abilities:

- distance leg kick strength – DLKS (m);
- jumping leg kick strength – JLKS (m);
- distance head kick – DHK (m);
- jumping head kick strength – JHKS (m);
- rectilinear leg kick accuracy - vertical target – RLKA (n);
- elevation leg kick accuracy - horizontal 20 m target – ELKA20 (n);
- volley kick – VK (n);
- header shot - vertical target – HS (n);
- elevation header shot - horizontal target – EHS (n);
- horizontal 20 s wall rebound – H20 (n);
- surface-to-wall rebound – SWR (n);
- ball advance speed - slalom – BAS1 (s);
- ball advance speed - in a semicircle – BAS2 (s);
- ball advance speed - at a right angle – BAS3 (s);
- ball advance speed - 20 m from a standing start – BAS4 (s);
- leg juggle – LJ (n).

A system of eight variables was applied to evaluate successful performance in football:

- success in technique performance – ST (n);
- success in the attacking phase of play – SA (n);
- success in the defensive phase of play – SD (n);
- individual creativity – IC (n);
- team responsibility – TR (n);
- engagement – EG (n);
- behavior – BH (n);
- overall success in the performance in play – OS (n).

Statistical analyses

In data processing, descriptive statistics were used to describe the measured variables, and a canonical correlation analysis was applied in order to determine the relationships and obtain maximum correlations between the analyzed spaces, i.e. between the system of specific motor variables and the system of variables used to evaluate successful performance in football play. In accordance with this method, normalization of variables was performed, and in- and between-group correlations were established for the two groups of variables. Canonical correlations between canonical factor pairs were calculated, and their significance was tested by Bartlett's χ^2 test with a marginal error of .05%.

RESULTS

Tables 1 and 2 present descriptive values of measured specific motor skills of football players and their performance success in football. It can be noticed that from the aspect

Table 1 Descriptive statistics – specific motor skills

	Mean	SD	cV	Min	Max
DLKS (m)	51.32	10.13	19.74	39.48	68.64
JLKS (m)	20.04	5.28	26.35	14.52	28.55
DHK (m)	4.96	0.63	12.70	2.84	6.37
JHKS (m)	6.25	0.58	9.28	3.32	10.12
RLKA (n)	10.35	3.48	33.62	3	16
ELKA20 (n)	6.21	4.13	66.51	1	20
VK (n)	3.46	1.74	50.29	1	7
HS (n)	14.72	4.8	32.61	2	15
EHS (n)	4.52	1.8	39.82	0	12
H20 (n)	5.86	2.7	46.08	1	13
SWR (n)	4.21	1.5	35.63	1	11
BAS1 (s)	18.37	1.98	10.78	12.63	28.57
BAS2 (s)	14.57	1.64	11.26	11.48	25.83
BAS3 (s)	15.54	1.88	12.10	12.97	26.41
BAS4 (s)	15.36	2.05	13.35	11.41	22.36
LJ (n)	42.3	15.8	37.35	21	79

Legend: DLKS – distance leg kick strength, JLKS – jumping leg kick strength, DHK – distance head kick, JHKS – jumping head kick strength, RLKA – rectilinear leg kick accuracy - vertical target, ELKA20 – elevation leg kick accuracy - horizontal 20 m target, VK – volley kick, HS – header shot - vertical target, EHS – elevation header shot - horizontal target, H20 – horizontal 20 s wall rebound, SWR – surface-to-wall rebound, BAS1 – ball advance speed - slalom, BAS2 – ball advance speed - in a semicircle, BAS3 – ball advance speed - at a right angle, BAS4 – ball advance speed - 20 m from a standing start, LJ – leg juggle.

of motor skills, football players are the most homogeneous in jumping head kick strength (cV=9.28), while their results are the least homogenous in the volley kick parameter (cV=50.29). When it comes to performance success, players are the most homogenous in the team responsibility parameter (cV=9.36), while they have the lowest homogeneity in the engagement parameter (cV=31.40).

Table 2 Descriptive statistics – performance success

	Mean	SD	cV	Min	Max
ST	3.26	0.89	27.30	1	5
SA	2.88	0.46	15.97	1	5
SD	3.41	0.52	15.25	1	5
IC	2.31	0.44	19.05	1	5
TR	3.42	0.32	9.36	2	5
EG	3.28	1.03	31.40	2	5
BH	3.21	0.78	24.30	1	5
OS	2.83	0.63	22.26	1	5

Legend: ST – success in technique performance, SA – success in the attacking phase of play, SD – success in the defensive phase of play, IC – individual creativity, TR – team responsibility, EG – engagement, BH – behavior, OS – overall success in the performance in play.

The results of determining the association between the specific motor skills and the criterion variables showed that these two spaces exhausted 86% of the variance of the analyzed system of variables tested by Bartlett's test, amounting to 413.50, and that there were statistically significant correlations of Can R.=0.93 for the first pair, Can R=0.86 for the second pair, Can R.=0.83 for the third pair, and Can R.=0.74 for the fourth pair of canonical factors at p=0.000 (Table 3).

Table 3 Canonical correlation analysis of the specific motor skills and criterion variables

Roots	Canl R	Can R%.	Chi-sqr.	df	Lambda	Sig.
0	0.93	0.86	413.50	120	0.00	0.00
1	0.86	0.75	278.40	98	0.01	0.00
2	0.83	0.69	184.89	78	0.06	0.00
3	0.74	0.55	105.96	60	0.20	0.00

The results of the analysis for the situational motor parameters revealed that the first canonical factor was characterized by high correlations with the following variables used to assess situational motor skills (Table 4): elevation leg kick accuracy – horizontal 20 m target (ELKA20), volley kick (VK), header shot – vertical target (HS), horizontal 20 s ball rebound (H20), surface-to-wall rebound (SWR), and leg juggle (LJ). The second canonical factor was predominantly defined by the variables used to assess distance head kick (DHK) and ball advance speed at 20 m (BAS4). The third canonical factor was mainly defined by the variables used to assess distance leg kick strength (DLKS) and jumping leg kick strength (JLKS). The fourth canonical factor was determined by a high correlation of the variable used to evaluate jumping head kick strength (JHKS).

Table 4 Factor structure of the specific motor skills (left set)

	CAN1	CAN2	CAN3	CAN4
DLKS	-0.23	-0.06	-0.47	-0.42
JLKS	-0.00	0.27	-0.63	-0.10
DHK	-0.11	0.32	-0.42	-0.10
JHKS	-0.07	0.25	-0.16	-0.50
RLKA	0.25	0.22	-0.33	-0.07
ELKA	0.42	0.39	0.08	0.32
VK	0.84	-0.01	-0.02	-0.17
HS	0.46	0.14	-0.08	-0.10
EHS	0.29	0.06	0.02	-0.15
H20	0.81	0.01	-0.22	-0.27
SWR	0.74	0.05	-0.29	-0.38
BAS1	0.13	-0.19	0.10	0.07
BAS2	0.12	0.09	0.11	0.24
BAS3	0.23	0.30	0.12	-0.06
BAS4	0.55	-0.08	0.17	-0.17
LJ	-0.23	-0.06	-0.47	-0.42

Legend: DLKS – distance leg kick strength, JLKS – jumping leg kick strength, DHK – distance head kick, JHKS – jumping head kick strength, RLKA – rectilinear leg kick accuracy - vertical target, ELKA20 – elevation leg kick accuracy - horizontal 20 m target, VK – volley kick, HS – header shot - vertical target, EHS – elevation header shot - horizontal target, H20 – horizontal 20 s wall rebound, SWR – surface-to-wall rebound, BAS1 – ball advance speed - slalom, BAS2 – ball advance speed - in a semicircle, BAS3 – ball advance speed - at a right angle, BAS4 – ball advance speed - 20 m from a standing start, LJ – leg juggle.

The analysis of the canonical factor matrix for the right set of variables revealed that the first isolated canonical factor highly correlated with the following criterion variables used to evaluate successful performance (Table 5): technique (ST), attack (SA), creativity (IC) and overall success (OS). The second canonical factor showed a high correlation with only one variable used to assess successful performance: engagement (EG). The third canonical factor also highly correlated with only one variable in success assessment: responsibility (TR). The analysis of the canonical factor matrix for the right set of variables did not reveal high correlations between the fourth isolated canonical factor and the criterion variables.

Table 5 Factor structure of specific motor skills (right set)

	CAN1	CAN2	CAN3	CAN4
ST	0.85	0.12	-0.02	-0.29
SA	0.68	0.21	-0.46	-0.48
SD	0.11	-0.05	0.12	0.07
IC	0.78	0.31	0.04	-0.34
TR	0.04	0.19	-0.33	-0.27
EG	0.07	0.55	-0.05	-0.45
BH	0.12	0.74	-0.26	0.03
OS	0.53	0.34	-0.44	0.03

Legend: ST – success in technique performance, SA – success in the attacking phase of play, SD – success in the defensive phase of play, IC – individual creativity, TR – team responsibility, EG – engagement, BH – behavior, OS – overall success in the performance in play.

DISCUSSION

This study investigated the relationship between specific motor skills and performance success in football play on a sample of 170 football players. As previously mentioned, the results of this study could lead to information about factors that affect performance success in football which could further contribute to the development of training technology and the selection process in football.

Tables 1 and 2 presents the descriptive values of measured specific motor skills of football players and their performance success in football, which shows that from the aspect of motor skills, football players are the most homogeneous in jumping head kick strength, while their results are the least homogenous in the volley kick parameter. Generally, it can be noticed that these participants have the highest homogeneity on those tests which contain fast distance movements with the ball (BAS1, BAS2, BAS3, BAS4, cV=11.8, on average), that is activities which are familiar to them and which they regularly practice during their training and matches. When it comes to performance success, players are the most homogenous in the team responsibility parameter, while they have the lowest homogeneity in the engagement parameter. This group of football players generally had the lowest grades when it comes to individual creativity (2.31), overall success in the performance in play (2.83) and success in the attack phase of play (2.88), while they had the best results in success in the defense phase of play (3.41) and team responsibility (3.42). These results are somewhat expected. Previous studies showed that lower league football players have lower values of some psychological characteristics (Memmert, Baker, & Bertsch, 2010; Vestberg, Gustafson, Maurex, Ingvar, & Petrović, 2012; Danielsen, Rodahl, Giske, & Høigaard, 2017), and general physical fitness parameters than those from higher leagues (Davis, Brewer, & Atkin, 1992; Cometti, Maffiuletti, Pousson, Chatard, & Maffulli, 2001). Since participants involved in this research played in the second and third football league, it can be assumed that they have relatively lower values for the afore mentioned properties, which could lead to low grades when it comes individual creativity, overall success and success in the attack phase.

Based on the results presented in Table 3, it can be concluded that these two spaces, that is motor skills and performance success, exhausted 86% of the variance of the analyzed system of variables tested by the Bartlett's test, amounting to 413.50, and that there were statistically significant correlations of Can R. = 0.93 for the first pair, Can R.=0.86 for the second pair, Can R.=0.83 for the third pair, and Can R.=0.74 for the fourth pair of canonical factors at p=0.000.

The results presented on the Tables 4 and 5, that is, the analysis for the situational motor parameters, revealed that the first canonical factor was characterized by high correlations with the elevation leg kick accuracy – the horizontal 20 m target (ELKA20), volley kick (VK), header shot – vertical target (HS), horizontal 20 s ball rebound (H20), surface-to-wall rebound (SWR), and leg juggle (LJ). The second canonical factor was predominantly defined by the variables used to assess the distance head kick (DHK) and ball advance speed at 20 m (BAS4), and can be defined as the canonical dimension of head kick strength and rectilinear ball advance speed. The third canonical factor was mainly defined by the variables used to assess distance leg kick strength (DLKS) and jumping leg kick strength (JLKS), and can be defined as the canonical dimension of leg kick strength, while the fourth canonical factor was determined by a high correlation of the variable used to evaluate jumping head kick strength (JHKS). The analysis of the canonical factor matrix for the right

set of variables revealed that the first isolated canonical factor highly correlated with the variables used to evaluate successful performance (Table 5): technique (ST), attack (SA), creativity (IC) and overall success (OS). It can be defined as the general canonical factor of success in football play. The second canonical factor showed a high correlation with only one variable used to assess successful performance: engagement (EG). It can be defined as the canonical factor of engagement in football play. The third canonical factor also highly correlated with only one variable in success assessment: responsibility (TR). It can be defined as the canonical factor of responsibility in football play. The analysis of the canonical factor matrix for the right set of variables did not reveal high correlations between the fourth isolated canonical factor and the criterion variables.

The relationship between the first pair of canonical factors can be understood as a basic measure of the correlation between these systems. Considering the magnitude of the shared variance between the first pair in the analyzed spaces, it can be argued that the two systems are correlated to a high degree. It has shown that situational motor skills have high correlations with performance success in the game of football. All the variables in either set have a positive sign so that situational motor skill variables can be said to have high canonical factor loadings achieved by the participants who had a better score in leg kick accuracy, volley kick, header shot accuracy, 20 s ball rebound, surface-to-wall rebound, and leg juggle, and who had a general success factor in football play. This association indicates that the participants whose performance in football play was more successful also had better situational motor skills.

The relationship between the first pair of canonical factors can be interpreted so that the mechanism for structuring movement is shown to be of great importance for the successful performance of tactical and technical elements in football players. The mechanism controlling a variety of coordinated operations is far more complex than the assumption on coordination structure might imply. Coordination is substantially saturated with the dimensions of strength, speed and balance, as many studies suggest. Complex central nervous system structures are of the utmost importance for the rapid execution of elaborate motor tasks. The movement structuring mechanism plays a special role, with the main function to program movement, especially since the performance of tasks requires that the entire body moves in space. The central nervous system manages movement through a system of hierarchical structure, including regulatory mechanisms, which will depend on the complexity of the motor task (Kurelić et al., 1975).

The second, third and fourth pairs of canonical factors cannot be meaningfully interpreted. The variability in the success in the game of football concerning the present sample was affected more by the difference in the learning process than by the relationships among potential skills or characteristics.

CONCLUSION

Correlations were established between the investigated spaces with four pairs of canonical factors and it was shown that situational motor skills have high correlations with performance success in the game of football. It is indicated that the participants whose performance in football play was more successful also had better situational motor skills and that the mechanism for structuring movement is shown to be of great importance for the

successful performance of tactical and technical elements in football players.

The results of this study confirmed the fact that football training to a large extent needs to be orientated towards the development of situational motor skills and that football coaches should select those individuals who possess a high level of these properties.

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RELACIJE IZMEĐU SITUACIONO-MOTORIČKIH SPOSOBOSTI I USPEŠNOSTI U IGRI FUDBALERA

Cilj istraživanja je da se utvrdi stepen povezanost sistema variajbli za procenu situaciono-motoričkih sposobnosti sa varijabliama za procenu uspešnosti u fudbalskoj igri. Istraživanje je sprovedeno na uzorku od 170 ispitanika, fudbalera – seniora. U istraživanju je primenjeno 16 varijabli za procenu specifčnih motoričkih sposobnosti i osam varijabli za procenu uspešnosti u fudbalskoj igri. Za utvrđivanje povezanosti (relacija) između navedenih prostora primenjena je kanonička korelaciona analiza. Na osnovu dobijenih rezultata, utvrđeno je da su istraživani prostori međusobno povezani sa četiri para kanoničkih faktora, odnosno da situaciono-motoričke sposobnosti imaju visoku povezanost sa uspešnosti u fudbalskoj igri (Can R. = 0.71, u proseku). Pokazalo se da ispitanici koji postižu bolje rezultate u uspešnosti u fudbalskoj igri imaju bolje situaciono-motoričke sposobnosti kao i da je za uspešno izvođenje taktičko tehničkih elemenata kod fudbalera od velike važnosti mehanizam za strukturiranje kretanja.

Ključne reči: *situaciono-motoričke sposobnosti, uspešnost u igri, fudbaleri*

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PROGRAMMING AND MANAGING METHODOLOGY OF EDUCATION TRAINING PROGRAMMES

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Abstract. *The main aim of this paper is to present theoretical knowledge and to answer the question of organizing, programming, conducting and managing the training process in order to achieve the best possible education training effects and to generate planned changes in the domain of the provided knowledge, abilities and skills of sportspeople. The findings have theoretical implications for methodological steps, programming algorithm, models and methods implemented in the process of programming and managing education training programmes and give an insight into the calculating, analysis, control and managing education training effects and changes. In accordance with the aim of the paper the multidimensionality of programming and managing methodology are highlighted. The presented methodological approach in designing education and training can be applied to all sports, however, not in its entirety, due to the specific methodological steps of some sports.*

Key words: *Algorithm, Programming Methodology, Training Effects, Training Changes*

INTRODUCTION

Programming and managing education training programmes are based on the theory of a stationary, current and transition state or regimen, the development theory, the capacity theory, the theory of structural and functional ability, the adaptation and modification theory, the theory of effects, the theory of muscle force production, the theory of acquiring motor algorithms and programmes, the theory of motor learning, control and manipulation, the integral theory of movement and muscle force production (Momirović et al., 1987; Bonacin, 2004; Tomić & Nemec, 2012; Milošević & Milošević, 2013; Milošević & Milošević, 2014; Milošević, Nemec, Životić, Milošević, Rajović,

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2014a; Milošević, Milošević, Nemec, Životic, & Radjo, 2014b; Milošević, Džoljić, Milošević, Yourkesh, & Behm, 2014c; Milošević et al., 2016; Nemec, Milošević, Nemec, & Milošević, 2016; Milošević, Nemec, Nemec, & Milošević, 2017).

Methodological concepts provide sportspeople (coaches, professors, athletes, etc.) with the knowledge regarding exactly what to do and why, as well as why not to, at all times, and what the outcome of the conducted training is (Milošević, Mudrić, Mudrić, & Milošević, 2012).

The latest experimental research results, training theories and mathematical models in the field of education and training significantly accelerate learning processes, as well as the adaptation and transformation processes of athletes (Momirović et al., 1987; Bonacin, 2004; Milošević et al., 2012; Milošević & Milošević, 2013; Milošević & Milošević, 2014; Milošević et al., 2014a; Milošević et al., 2014b; Milošević et al., 2014c; Milošević et al., 2016; Nemec et al., 2016; Milošević et al., 2017; Milošević, Nemec, Nemec, & Milošević, 2018).

Special attention is dedicated to the methods for data gathering and feedback analysis on the general output from education training effects and change managing systems (Momirović et al., 1987; Bonacin, 2004; Milošević et al., 2012; Milošević & Milošević, 2013; Milošević & Milošević 2014; Milošević et al., 2014a; Milošević et al., 2014b; Milošević et al., 2014c; Nemec et al., 2016; Milošević et al., 2016; Milošević et al., 2018).

Data acquisition and storing in specialized databases, and their complex structure analysis by stochastic and deterministic mathematical methods and procedures are quick and simple (Momirović et al., 1987; Bonacin, 2004; Milošević & Milošević 2014).

Methodological concepts provide determining equations which depict various specific movements of athletes, force production, education training effects and changes in knowledge, force, aerobic and anaerobic capacities, the dynamics of an athlete's progress, their energy reserves and energy processes, the pace of their recovery while training and intermissions, the speed, time and level of supercompensation in various managing fields (Momirović et al., 1987; Bonacin, 2004; Milošević & Milošević, 2013; Milošević & Milošević 2014; Milošević et al., 2014a; Milošević et al., 2014b; Milošević et al., 2014c; Nemec et al., 2016; Milošević et al., 2016; Milošević et al., 2018). It provides a graphic presentation, print-outs of analysis results and reports, comparison of athletes, classes, and groups with the results of European and world athletes, and sequential search for the best possible training for an individual, class, group or sports team (Bonacin, 2004; Momirović et al., 1987; Milošević & Milošević, 2014). Hence, it provides direct managing of education and training sessions, and managing and directing programmed current and cumulative training effects and changes (Momirović et al., 1987; Bonacin, 2004; Milošević & Milošević, 2014).

The main aim of this paper is to present theoretical knowledge and to answer the question of organizing, programming, conducting and managing training process in order to achieve the best possible education training effects and to generate planned changes in the domain of the provided knowledge, abilities and skills of sportspeople.

THEORETICAL FRAMEWORK FOR PROGRAMMING AND MANAGING EDUCATION TRAINING PROGRAMMES

Semantic logical algorithm definition

Step one: Defining the population: age, gender, sensitive zone data, health status, morphological status, the data on psychological status, the data on physical status, capacities and the level of technical and tactical skills of both individuals and the entire student or competing population (Tomić & Nemec, 2012).

Step two: Defining variables for the assessment of athletes' abilities, their skills, advancement, energy and tactical requirements of fights – competitions, physical condition of sportspeople, aerobic, alactate and lactate education training, speed and force training, cognitive effects and changes. In addition, mechanic, myogenic, neurogenic, biochemical and physiological effects and changes in athletes' bodies (Milošević & Milošević, 2013; Milošević & Milošević, 2014; Milošević, et al., 2014a; Milošević, et al., 2014b; Milošević, et al., 2014c; Nemec, et al., 2016; Milošević, et al., 2016; Radenković, Bubanj, Berić, Stanković, Stojanović, Stojić. 2018; Stojanović, Radenković, Bubanj, Stanković, 2019).

Step three: Defining objects of management (educational objects, objects that define the fight – competition, then aerobic, anaerobic and energy status, status in speed and force, etc.) which are consequently changed under the influence of education and training (Momirović, et al., 1987; Bonacin, 2004; Milošević & Milošević 2013; Milošević & Milošević, 2014; Milošević et al., 2014a; Milošević et al., 2014b; Milošević et al., 2014c; Nemec et al., 2016; Milošević et al., 2016).

Step four: Defining tests (the programme and procedure for measuring metric units) for assessment of methods, education training, education training effects and changes (Momirović et al., 1987; Bonacin, 2004; Milošević & Milošević, 2013; Milošević & Milošević, 2014; Milošević et al., 2014a; Milošević et al., 2014b; Milošević et al., 2014c; Nemec et al., 2016; Milošević et al., 2016).

Step five: Defining operations for calculating values in set units (Momirović et al., 1987; Bonacin, 2004; Nemec et al., 2016).

Step six: Defining experiments for conducting diagnostics of the physical and education status and training status of an individual, group, team and specific age group (Momirović et al., 1987; Bonacin, 2004; Milošević & Milošević, 2013; Milošević & Milošević, 2014; Milošević et al., 2014a; Milošević et al., 2014b; Milošević et al., 2014c; Nemec et al., 2016; Milošević et al., 2016).

Step seven: Calculating the initial state and capacity (Momirović et al., 1987; Bonacin, 2004; Milošević & Milošević, 2013; Milošević & Milošević, 2014; Milošević et al., 2014a; Milošević, et al., 2014b; Milošević, et al., 2014c; Nemec et al., 2016; Milošević et al., 2016; Milošević et al., 2018).

Step eight: Calculating and evaluating dynamics of increase in observed variables of an individual, group and population according to the abilities of sportspeople and in accordance with the competition requirements (Momirović et al., 1987; Bonacin, 2004; Milošević & Milošević, 2014; Milošević et al., 2018).

Step nine: Calculating the ideal final state of an individual, group (taxon), team and population in the observed variables (Momirović et al., 1987; Bonacin, 2004; Milošević & Milošević, 2014; Milošević et al., 2018).

Step ten: Differentiating between the initial, transition, and final state among individuals and groups in a team or school (Momirović et al., 1987; Bonacin, 2004; Milošević & Milošević, 2014).

Step eleven: Defining material basis (conditions) where education training or education is performed: the number of playgrounds, gymnasiums, open and enclosed fields, gyms, equipment, the number of coaches, the amount of available finances, and competition calendar (Tomić & Nemec, 2012).

Step twelve: Defining time structure of education training structure: the duration of specific training in minutes, the number of training sessions per day, the number of training sessions per week, the number of training sessions per month or year, the duration of a training session per day, week, month, year expressed in minutes, the transition of daily, weekly, and education training regimens; calculating time relation between physical and technical tactical preparation according to age and training; yearly, monthly, weekly and daily plans; defining periods without competitions, periods with one, two or more competitions per week, and the total number of competitions per year according to the age group (Momirović et al., 1987; Bonacin, 2004; Milošević & Milošević 2013; Milošević & Milošević 2014; Milošević et al., 2014a; Milošević et al., 2014b; Milošević et al., 2014c; Nemec et al., 2016; Milošević et al., 2016).

Step thirteen: Defining the set of classical and specific education training processes used by all age groups throughout perennial education training sessions (Momirović et al., 1987; Bonacin, 2004; Milošević & Milošević, 2013; Milošević & Milošević, 2014; Milošević et al., 2014a; Milošević et al., 2014b; Milošević et al., 2014c; Nemec et al., 2016; Milošević et al., 2016).

Step fourteen: Defining the set of education training methods which are used with all age groups during a perennial education training period (Momirović et al., 1987; Bonacin, 2004; Milošević & Milošević, 2013; Milošević & Milošević, 2014; Milošević et al., 2014a; Milošević et al., 2014b; Milošević et al., 2014c; Nemec et al., 2016; Milošević et al., 2016).

Step fifteen: Defining the voluntary influence of education and training: field (basic, targeted and advanced or situational training), the manner of influence (establishing, developing, managing, renewing), the training regimen (aerobic, anaerobic, etc.), the type of influence (all skills and abilities which are developed according to the given age groups) (Milošević & Milošević, 2014).

Step sixteen: Data input on education training programmes: the ordinal number of one or more training sessions, date or dates of training sessions for which the programmes is designed, the athlete's name and surname or the name of the group (team – team 1 or team 2), the age of the athletes (Milošević & Milošević, 2014).

Step seventeen: Defining (setting) training goals, that is, calculating current and cumulative education training effects for individual athletes for one or more training sessions in his/her field of expertise, aerobic, anaerobic, speed and force based on the diagnosed initial state, dynamics of athlete's advancement, the requirements of fights and material conditions (Momirović et al., 1987; Bonacin, 2004; Tomić & Nemec, 2012; Milošević & Milošević, 2013; Milošević & Milošević, 2014; Milošević et al., 2014a; Milošević et al., 2014b; Milošević et al., 2014c; Nemec et al., 2016; Milošević et al., 2016).

Step eighteen (start programming individual training sessions): Defining goals and tasks for specific training session for the particular individual athlete, age group, group or team (Momirović et al., 1987; Bonacin, 2004; Tomić & Nemec, 2012; Milošević & Milošević

2013; Milošević & Milošević, 2014; Milošević et al., 2014a; Milošević et al., 2014b; Milošević et al., 2014c; Nemec et al., 2016; Milošević et al., 2016).

Step nineteen: Defining time structure of specific training session which corresponds to material conditions, age, skills level, current status and the dynamics of individual, team or group advancement which shall stimulate meeting the set goals (Momirović et al., 1987; Bonacin, 2004; Tomić & Nemec, 2012; Milošević & Milošević, 2013; Milošević & Milošević, 2014; Milošević et al., 2014a; Milošević et al., 2014b; Milošević et al., 2014c; Nemec et al., 2016; Milošević et al., 2016).

Step twenty: Calculating the final state according to the exact time of education or training session, material conditions (equipment, halls, courts, finances, competition calendar, etc.), set goals, the initial state of age group for which the final states are being projected, and the rules for changing certain variables, that is, components of the athlete's state in relation to sensitive zones (Momirović et al., 1987; Bonacin, 2004; Milošević & Milošević 2014).

Step twenty-one: Choosing a wider range of age-appropriate classical and specific training methods, with the corresponding level of skills and abilities of an individual or group, time structure, training period (periods without held competitions, periods with one or more competitions per week) and set goals for the particular training session (Milošević & Milošević, 2013; Milošević & Milošević, 2014; Milošević et al., 2014a; Milošević et al., 2014b; Milošević et al., 2014c; Nemec et al., 2016; Milošević et al., 2016).

Step twenty-two: Choosing a wider range of training methods according to the intensity of influence on skills and abilities of an individual or a group, as those which enable achieving set training goals for a particular training session at the moment of the training period (periods without held competitions, periods with one or more competitions per week) while using the chosen methods. Every presented method is described in accordance with the effects, the number of exercises and combinations of exercises, the number of repetitions of exercises or combinations, the duration of a single repetition, the amount and duration of intermissions, the duration of training sessions or the number of series, the speed of doing an exercise or combination, that is the regimen (Milošević & Milošević, 2013; Milošević & Milošević, 2014; Milošević et al., 2014a; Milošević et al., 2014b; Milošević et al., 2014c; Nemec, et al., 2016; Milošević et al., 2016).

Step twenty-three: Defining voluntary influence (effects and changes - advancement) of set training methods and models at the predefined time period of an athlete or a group of individuals. Then evaluating their influence and choosing a specific training session solely for those who match the set goals, programmed changes, the dynamics of acquiring skills and abilities of individuals in the defined time for training (Momirović et al., 1987; Bonacin, 2004).

Step twenty-four: Calculating capacity variables which an athlete is able to perform, calculate and evaluate the amount of individual training which is realised during particular training sessions (the information, force production, energy production, the speed of performance, the duration of performance, spatial perimeter of performance, the amount and frequency of performed training, the frequency and duration of intermissions, etc.) which generates programmed current or cumulative effects and changes (the advancement in skills, speed, the quantity of produced force, energy, lactic acid, oxygen debt, consumable oxygen, glycogen, phosphocreatine, the increase in force production, speed, energy, offense, defence, motion, recovery, decomposition and re-synthesis of energisers, etc.) for

one or more training sessions (Momirović et al., 1987; Bonacin, 2004; Milošević & Milošević, 2014; Nemec et al., 2016).

Step twenty-five (start evaluating): Quality control of education training programmes – observer Graph 2 (Momirović et al., 1987; Bonacin, 2004; Milošević & Milošević, 2014; Nemec et al., 2016).

Step twenty-six: Evaluating education training effects and changes – observer Graph 2 (Momirović et al., 1987; Bonacin, 2004; Milošević & Milošević, 2013; Milošević & Milošević, 2014; Milošević et al., 2014a; Milošević et al., 2014b; Milošević et al., 2014c; Nemec et al., 2016; Milošević et al., 2016).

Step twenty-seven: An education training programme which is programmed in the aforementioned manner is the basic input variable (U) in the managing model, Graph 1 (Momirović et al., 1987; Bonacin, 2004; Milošević & Milošević, 2013; Milošević & Milošević, 2014; Milošević et al., 2014a; Milošević et al., 2014b; Milošević et al., 2014c; Nemec et al., 2016; Milošević et al., 2016).

Step twenty-eight: Generating and providing data input of the most effective training programmes for the basic and advanced sports education, and particularly education for managing fights and competitions for aerobic, alactate and lactate training sessions, as training sessions in speed and force, as well as programming current and cumulative education, mechanic, myogenic, neurogenic, biochemical and physiological effects and changes, that is, advancement which generates programmed training for one or more training sessions of a certain age, team, group or an individual athlete during a training period of one week, month or year – model output, Graph 1 (Momirović et al., 1987; Bonacin, 2004; Milošević & Milošević, 2014).

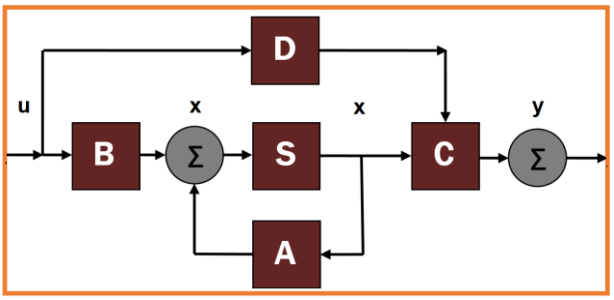
The model for managing education training effects and changes

Athletes' performance is evaluated through the effects, quantitative and qualitative changes, and specific skills and processes which influence the quality and speed realisation of their movements. The desired effects are generated by applying education training effects (operators) in accordance with the set goals (Tomić & Nemec, 2012; Milošević & Milošević, 2014; Milošević et al., 2014a; Milošević et al., 2014b; Milošević et al., 2014c; Nemec et al., 2016; Milošević et al., 2016). The state model is used as the basis (Milošević & Milošević 2014) for rational managing of effects and changes. Consequently, the state of the system presents the smallest set of factors which at a particular time frame enables (Momirović et al., 1987; Bonacin, 2004; Milošević & Milošević 2014) the following:

- A thorough explanation of athletes' functioning and characteristics as a biological system (the manner of functioning, adaptive characteristics, regulation mechanisms, information and energy processes, relations, effects, and changes);
- Predicting an athlete's behaviour;
- Simulation in order to determine optimal changes in athletes' adaptive characteristics, processes and specific skills according to the requirements of sports fields and applied programmes.

An individual or group transitions from one state (initial) to the other (transitive or final) projected state, herein. Therefore, the state of an individual athlete or group is presented via state variables, whereas the set of all state variables shows the state space, while the motion through trajectories of state space is defined as system behaviour (of an

individual athlete or a group) in the given space (Milošević & Milošević, 2014). The state of the system is shown via motor variables (muscle contraction and bioenergetics potential, specific motor skills) since they are the prominent parts of every motion. Other variables such as psychological and morphological, variables showing energy and tactical requirements of combats-competitions, and others influence the quality and speed of specific movement in sports, directly or serve as a reducer or intensifier of motor variable' influences. Thus, it is rather necessary to be familiar with their relation to motor variables for the purpose of improving management (Milošević & Milošević, 2014). With such a predefined state model, the general model of managing input (space for input variables U), state space (X), and output (space for output variables Y) are shown in Graph 1 where operators (blocks) depict the following transformations:



Graph 1 State model (Milošević & Milošević, 2014)

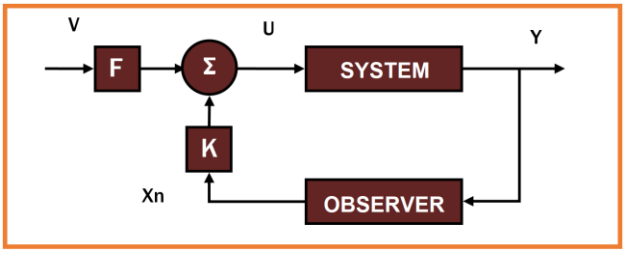
A : X → X_{n+1} – system matrix,
B : U → X – input matrix,
C : X → Y – output matrix,
D : U → Y – direct input-output relation matrix, while S shows current response operator of an athlete's organism between two transitional states.

Matrix A shows training operators (programmes), that is, the matrix of training system functioning. It consists of the coefficient presenting the relation between training which is depicted via models, methods, scope and intensity, distribution of training and education stimuli, other environmental factors together with effects and changes which are generated by the scope of the state of the system. Matrix B is the managing matrix (control operator), that is, the matrix of input variable (U) decomposition. Matrix C is the mechanism of system's functional composition of decomposed space state (X). Matrix D shows the relation between the criteria of system management in the managing space. System performance is presented in its mathematical form by the following equations:

$$X_{n+1} = Ax_n + Bu, \quad Y_n = Cx_n + Du, \quad x(t_0) = x_0$$

The data that follows provide the information on the main issue while programming and managing the management model. It provides adequate support in the form of gathering greater amount of precise output data at the right time (current and cumulative effects and changes generated by applying education training programmes) which describes the system

(by using sub-systems of binary relations according to the state or system output). The issue of state recording is resolved through observer constitution (Graph 2), that is the mechanism for evaluating or measuring relevant state variables and output of the given system (Milošević & Milošević, 2014). Such an expanded model manages the observer, operators of the reference input value (F) and feedback (K), as the space of evaluated states (X) and reference stimulus (V) which is shown in Graph 2.



Graph 2 Observer (Milošević & Milošević, 2014) Σ

As opposed to the system matrix A representing natural auto regulation system behaviour as shown in Graph 1, the observer is identified as a mechanism for observing variables of the manifested state in extended form, which in combination with the reference operator input F and imposed feedback (regulator K) portrays a forced managing system of athletes' states.

The aforementioned managing concept provides more thorough dealing with this issue which implies, accepts and incorporates wider social interest, financial limitations and other non-specific factors.

The extended system showing an estimated athlete's state is presented in the form of the following differential equation:

$$x_{n+1} = A_0 x_n + B_0 Y_0 + Bu,$$

A_0, B_0 shows the observer's specific characteristics presented mathematically.

Information technology support for the model of managing education training effects and changes

Due to the fact that the suggested methodology requires complex operations consisting of a greater number of variables, and applying relatively complex mathematical and statistical procedures, it is necessary to provide information technology support by programming a hardware and software system with automatic data gathering and processing (Milošević & Milošević, 2014). The main goal of this system is to gather all the data and information needed for planning, programming and managing training processes, observing and predicting athletes' states in the scope of their skills and performance technique. System specific goals include (Momirović et al., 1987; Bonacin, 2004; Milošević & Milošević, 2014):

- Determining and observing specific skills based on the number of selected and organised pieces of information which are comprehensible and applicable to the experts in the field;

- Providing adequate information needed for programming, managing and predicting the effects of sporting advancement through automatic data gathering, and data compiled through measuring and testing;
- Profiling the data on individual athlete's states based on gathered and relevant information;
- Programming various education training programmes and managing generated effects and changes;
- Providing relevant information to experts and trainers as the basis for strategic planning and evaluation of expert work in the field;
- Performing rational and detailed selection of potential sports staff based on the collected data.

In order to meet the demands, it is essential to form the following four subsystems: 1) the Motor skills subsystem; 2) Specific skills subsystem; 3) Information on data and training effect programmes subsystem; 4) The subsystem for programming education training programmes (Patsiaouras, Moustakidis, Charitonidis, & Kokaridas, 2011; Veličković, Petković, & Petković, 2013; Milošević & Milošević, 2014; Milošević et al., 2018).

Apart from the aforementioned subsystems two additional subsystems, as an integral part of the system, are needed in order to collect data on morphological and psychological status (Milošević & Milošević, 2014). A database for every mentioned subsystem is created while the usage of various mathematical and statistical operations is used as an integral part of the subsystem for programming training programmes. It is easy to manage training effects and changes by performing those operations for the analysis of certain education training programmes on an athlete's change of state. As the effect of the completed analysis of the subsystem generates programming, such training programmes are entirely adjusted to meeting the set goals and tasks in a particular sports field or training session.

Consequently, the purpose of the system is acquiring, input and data analysis, programming and managing education training programmes. Technical support for programming and managing methodology for education training programmes are software programmes for force acquisition, electromyography, timing, photocells, contact platforms, sensors, the equipment needed for competitions and combats analysis, modules for data input, calculating coefficient of exponential equations, for calculating spline method coefficient equation, for graphing equations, client report, reports, writing and report analysis and peripheral equipment such as biomechanical measuring systems, force platform, video system, probes, dynamometer, functional capacity evaluation equipment, cardiovascular endurance, biochemical testing, postural status and anthropometric testing (Veličković et al., 2016).

Methods for developing algorithm and performing analysis for education training effects and changes

In certain steps for programming education training programmes a model of similarities and differences is used, like a residue, linear stochastic model, component, taxonomy, canonical and regression model (Momirović et al., 1987; Milošević & Milošević, 2014).

Defining current and cumulative training effects (goals) of an individual athlete for one or more training sessions is performed in accordance with the diagnosed initial state or transition state and energy requirements of competitions by applying polynomial

trending (Momirović et al., 1987; Bonacin, 2004; Milošević & Milošević, 2014; Nemec et al., 2016).

Calculating performance capacity variables of an athlete and programming the quantity of force production, the speed of performance, the duration of performance, the spatial perimeter of performance, the amount and frequency of performed training, the frequency and duration of intermissions, etc., which generate programmed current or cumulative effects and changes for one or more training sessions, are performed by using a non-linear multiple regression method (Momirović et al., 1987; Bonacin, 2004; Milošević & Milošević, 2014; Nemec et al., 2016).

The analysis and evaluation of technical, tactical, aerobic, alactate and lactate training and force training, its current and cumulative mechanic, myogenic, neurogenic, biochemical and physiological effects of teams, national teams, or an entire sports field require canonical and regression methods with or without separating previous transitive states (Momirović et al., 1987; Bonacin, 2004; Milošević & Milošević, 2014).

The analysis of practical and theoretical training effects on the structure of groups, teams, and national teams work with different factor models and methods. Comparing the energy state of one training session to the energy state of one fight or any other first-rate competition is performed by applying non-linear factor solutions. The efficiency of the education training process is determined through the degree of similarity (Mahalanobis distance) of education training effects of one training session and energy force requirements of one fight or any other international competition (discriminant analysis). Comparative analysis, evaluation of various education training programmes and the selection of the best among them is performed by applying taxonomy and factor methods. Determining metric characteristics of observed variables, athlete's classification, and normative evaluation of education training effects is performed by conducting factor and robust discriminant analysis (Momirović et al., 1987; Bonacin, 2004; Milošević & Milošević, 2014; Brezić, 2016).

Defining voluntary influence (field, the manner of influence, the type of influence, the regimen of influence, the intensity of influence) of training models and methods at the set time is completed through applying canonical and non-linear multiple analysis (Momirović et al., 1987; Bonacin, 2004; Milošević & Milošević, 2014).

Defining the final number of training models and methods is completed through non-linear factor analysis solutions (Momirović et al., 1987; Milošević & Milošević, 2014).

The analysis of quantitative education training changes (technical, tactical, mechanic, myogenic, neurogenic, energy, biochemical and physiological) of teams, national teams, or the entire sports field is completed through applying: differences model, similarities model, residue model, linear stochastic model and canonical model (Momirović et al., 1987; Bonacin, 2004; Milošević & Milošević, 2014).

The analysis of qualitative education training changes is conducted by applying a component model, taxonomy model, canonical model and the analysis of regression parameters (Momirović et al., 1987; Milošević & Milošević, 2014).

The generated changes are analysed by applying spectral analysis of state changes of one method (technical tactical skills, aerobic, anaerobic, force, etc.), spectral analysis of the curve of change of one variable registered on more subjects and at various points in time, the analysis of absolute and relative individual changes and the analysis of polynomial trending changes of an individual athlete, team, national team or the entire sports field (Momirović et al., 1987; Bonacin, 2004; Milošević & Milošević, 2014).

Calculating the function of training changes of an individual, team or a national team at a certain time, determining metric characteristics of observed variables and forming a normative for training changes evaluation (advancement) is completed by conducting taxonomy and non-linear regression analysis (Momirović et al., 1987; Bonacin, 2004; Milošević & Milošević, 2014).

CONCLUSION

The findings have theoretical implications for methodological steps, programming algorithms, models and methods implemented in the process of programming and managing education training programmes and give an insight into the calculating, analysis, control and managing of education training effects and changes. In accordance with the aim of the paper the multidimensionality of programming and managing methodology are highlighted. The presented methodological approach in designing education and training can be applied to all sports, however, not in its entirety, due to the specific methodological steps of some sports.

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METODOLOGIJA PROGRAMIRANJA I UPRAVLJANJA OBRAZOVNIH TRENAŽNIH PROGRAMA

Osnovni cilj ovog rada bio je da se predstavi teorijsko znanje i da se odgovori na pitanje organizacije, programiranja, vođenja i upravljanja trenažnim procesom u cilju postizanja najboljih mogućih obrazovnih efekata treninga i generisanja planiranih promena u domenu pruženih znanja, sposobnosti i veštine ljudi uključenih u sport. Nalazi imaju teorijske implikacije na metodološke korake, algoritam programiranja, modele i metode primenjene u procesu programiranja i upravljanja programima obrazovanja i daju uvid u izračunavanje, analizu, kontrolu i upravljanje efektima treninga i promenama. U skladu sa ciljem rada, istaknuta je višedimenzionalnost programa i upravljačkih kapaciteta. Predstavljeni metodološki pristup u dizajniranju obrazovanja i treninga može se primeniti na sve sportove, ali ne u celosti, zbog specifičnih metodoloških koraka nekih sportova.

Ključne reči: *algoritam, metodologija programiranja, efekti treninga, trenažne promene.*

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Research article

THE EFFECTS OF REGULAR CLASSES AND CLASSES WITH ADDITIONAL EXERCISES ON STUDENTS' MOTOR ABILITIES

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Abstract. *The aim of the research was to examine and compare the effects of physical education (PE) classes with additional swimming training in relation to the regular teaching of PE on the motor abilities of students of a younger school age. A sample of 100 respondents was divided into two sub-samples in relation to the number of weekly exercises: a sub-sample of 50 students (control group-CG) with regular PE and a sub-sample of 50 students (experimental group-EG) who, besides their regular classes, had two additional weekly exercises in the form of swimming training. The training program of swimming courses was conducted for three months in the first semester of the 2015/2016 school year. Five standardized Eurofit battery tests were used to evaluate their motor abilities. The obtained results indicate that two additional weekly exercises in the form of swimming training caused statistically significant differences between the EG and the CG in long distance jogging, sit-ups for 30 s and a 20 m run test with a progressive increase in speed. The results suggest that swimming in addition to the already known impact on physiological characteristics positively influences the transformation of motor abilities in students of a younger school age.*

Key words: *Physical Education, Swimming, Motor Skills, Students of a Younger School Age*

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INTRODUCTION

According to the experts, the way of teaching which today dominates in most elementary schools has numerous disadvantages. Teaching is subjected to criticism because it is thought to offer students superficial and useless knowledge that turns a student into a "wiseacre encyclopaedist" with a bunch of facts that often cannot be used in new and different situations and practical activities (Healey, 2005; Onurkan Aliusta & Özer, 2017). On the other hand, the increasingly frequent use of educational technology inventions seriously jeopardizes the physical activity of students, who spend more time sitting on school benches (acquiring information from the overwhelming curriculum envisaged by the program), or in front of their computers and televisions (Swamidass & Vulasa, 2009; Kloos et al., 2019).

It is important to note that human movement is not only closely related to physical, but also to the mental, social and psychological development. The future of our society depends on the physical potentials, mental abilities, emotional stability and social adaptation of children who are now growing and whose future we are concerned about. The conditions in which children grow and develop are not always stimulating. Urbanization, the modern way of life, mechanization, the burden of children with intellectual activities, the overall relationship of the social environment and its influence on children and their activities in it no longer act as stimuli, they do not encourage them to move. As a result, the goal of teaching physical education (PE) is to meet the needs of students for movement, contribute to the increase of their adaptive and creative abilities in contemporary living and working conditions, develop a health culture necessary for the preservation of health and the creation of a lasting habit of incorporating physical exercise into everyday life (Sawyer, 2004; Davies et al., 2013).

In spite of clearly defined goals, emphasis is still placed on the acquisition of knowledge in practice, and the physical engagement of students is ignored. Most authors (Radovanović et al., 2009; Kalaja, Jaakkola, Liukkonen, & Watt, 2010; Tošić, 2011; Pešić et al., 2016) present the opinion that students need to provide physical engagement and movement in water at the earliest age. Swimming training can begin very early because swimming is the most appropriate content of PE in all ages. The fact is that the acquisition of swimming skills at the present time is limited by material-technical conditions and low efficiency of the process of initial swimming lessons (Farrell, 2007; Macejková, Masaryková, & Labudová, 2008; Barbosa, Marinho, Costa, & Silva, 2011).

Swimming training among children of a young school age is carried out mainly on the basis of methodological principles of training in swimming clubs. In the course of working with children of a younger school age, in addition to training a child to manage only in water, the deformities (most often of the spinal column) are prevented through training, which usually occurs with the child starting school. Due to poor musculature, physical inactivity, long sitting, children often experience deformities of the spinal column, which, apart from the aesthetic appearance, may adversely affect the functional abilities of certain organs, especially the locomotor apparatus. However, in the water, when the body is in a horizontal position, without load on the spine, movements are carried out without great effort, burdening the muscularity of the body evenly and effectively, and especially the muscles of the back, chest and shoulder belt. This work positively influences the strength of the entire musculature, which leads to corrections of

the incorrect position of the body. Swimming allows the increased functioning of all systems in the body, primarily of the heart and respiratory system (Sutarto, Wahab, & Zin, 2010). In addition, frequent changes in the outside temperature and water temperature activate the thermoregulatory protection mechanism of the body, and as a result, the body's resistance to various diseases increases. Staying in water contributes to the maintenance of body hygiene, improves the function of the skin, and at the same time increases its protective role.

The aim of the research was to examine and compare the effects of PE classes with additional swimming training in relation to the regular PE classes on the motor abilities of students of a younger school age.

METHODS

The research has a longitudinal experimental character (a pedagogical experiment with parallel groups of students of a younger school age), realized for the duration of one semester, in which the teaching of PE was organized in 30 school lessons. With the written consent of the schools and the parents, assessment of motor skills was carried out during regular PE classes. Estimates were made by professors of PE with previous research experience, so that the initial and final tests were performed by the same persons. For initial and final assessment, five variables of the Eurofit battery (Tsigilis, Douda, & Tokmakidis, 2002; Gulías-González, Sánchez-López, Olivas-Bravo, Solera-Martínez, & Martínez-Vizcaíno, 2014) were applied. It took three hours and the dynamics was as follows: during the first hour, the level of flexibility – the sit and reach test (EFPS in cm) and the explosive power of leg muscles - a long-range jump (EFSD in cm) were evaluated. During the second hour the repetitive strength of the abdominal muscles and the hip joint i.e., sit-ups for 30 s (EFLS in reps) and the isometric muscle force of the upper body and the bent arm hang i.e., strength and endurance (EFZG in s) were evaluated. Finally, during the third hour maximum aerobic endurance i.e., steady running at 20 m with progressive speed increase (EFIZ in s) was evaluated. The initial assessment established the level of motor skills, with the intention of raising it by means of the experimental program of swimming training, and evaluating it by the means of a final assessment at the end of the semester.

Sample of participants

The study was conducted on a sample of 100 participants aged 11±6 years (Mean±SD), fourth grade elementary school children from the city of Niš.

The sample of participants was divided into two sub-samples. The CG (n=50, body height 152.09±5.68 cm, body mass 44.37±8.18 kg, Mean±SD) consisted of participants who only attended regular PE classes. The EG of participants (n=50, body height 150.02±6.90 cm, body mass 41.55±7.06 kg, Mean±SD) had two additional weekly exercises in the form of swimming training (a total of 24 classes) in addition to their regular PE. All of the participants were healthy on the day of the initial and final assessment.

Description of the applied experimental program of swimming training

The experimental program of training for non-swimmers was realized after obtaining consent from the school and parents, for a period of 12 weeks. The frequency of exercise was twice a week for 45 min., and the total number of hours was 24. The experimental treatment was conducted with the fourth grade participants from the "Bubanjski heroji" elementary school in Niš, while the control treatment was realized with fourth grade participants from the "Stefan Nemanja" elementary school in Niš. At the end of the initial assessment, a 24-hour course started, during which the planned content was realized. The swimming training program was realized at the pools of the Sports Center "Čair" in Niš. The CG worked according to the standard plan of PE teaching (teaching content from the official PE program). The EG worked on the same program content with two additional exercises weekly in the form of swimming training. The swimming training program included: checking swimming knowledge, dryland workouts, breathing and looking under water exercises, getting used to being in water exercises, horizontal positioning and water skating exercises, water games, diving, jumping and learning basic swimming techniques. The elements that were used during the course of swimming training were selected in accordance with the relevant recommendations for training non-swimmers (Benjanuvatra, Edmunds, & Blanksby, 2007; Girold, Maurin, Dugué, Chatard, & Millet, 2007; Jorgić et al., 2010; Pyne & Sharp, 2014; Stanković, Milanović, & Marković, 2015). The goal of the swimming training program was to alleviate the fear of water, to get the participants to be alone in the water, for them to look under water, to keep lying on their back and stomach, to skate through the water, to dive, jump from the edge of the pool legs or head first and swim 25 to 50 m practicing any type of stroke.

Data processing

The following descriptive statistics were calculated: Mean value (Mean), standard deviation (SD), coefficient of variation (Cv%) and Kolmogorov-Smirnov test (KS-p). To test the significance of differences in the arithmetic means on the initial and final assessment of the results of the study, a univariate variance analysis (ANOVA) was applied for each group of participants.

RESULTS

The mean values of all the applied tests show that the CG achieved better results at the final assessment in all variables, except for the bent arm hang. The achievements of the EG in the final assessment were better for all the variables.

The largest deviation from the mean value at the initial and final assessment, as indicated by the standard deviation, is in the case of the 20m run (EFIZ), with the value of the standard deviation of the CG at an initial assessment of 50.55, and at the final one, 43.43. Similar findings were determined for the EG where the value of the standard deviation at the initial assessment is 63.24, and at the final 64.21. The lowest deviations from the mean values at the initial and final assessments of both groups are in the case of variables of the sit and reach test (EFPS).

Table 1 Descriptive indicators and differences at the univariate level among the participants at the initial assessment

	Control group				Experimental group				ANOVA	
Variables	Mean	SD	Cv%	KS-p	Mean	SD	Cv%	KS-p	F	p
EFPS (cm)	17.74	6.75	38.06	.886	19.16	4.63	24.15	.837	1.505	.223
EFSD (cm)	143.21	30.81	21.51	.899	156.36	25.81	16.51	.986	5.353	**.023**
EFLS (reps)	18.36	5.64	30.75	.998	21.20	6.57	31.01	.452	5.370	**.023**
EFZG (s)	33.00	27.95	84.68	.094	22.05	17.50	79.39	.369	5.513	**.021**
EFIZ (s)	168.90	50.55	29.93	.728	191.84	63.24	32.97	.984	4.014	**.048**

Legend: Mean – arithmetic mean value; SD – standard deviation; Cv% - coefficient of variation; KS-p – Kolmogorov-Smirnov test; F – value of F test; p – level of statistical significance

In addition to this, the numerical values of the coefficients of variation indicate the homogeneity and heterogeneity of the set. The most homogeneous parameter at the initial and final assessments of both groups is the long-range jump (EFSD), while the smallest homogeneity was determined for the elevation in the joint at the initial and final assessments of both groups. The normal distribution of values was determined in all five experimental and CG variables of the experimental and CG at the initial and final assessment. The values of the Kolmogorov-Smirnov test indicate this.

In order to determine whether the observed differences were statistically significant, a univariate variance analysis (ANOVA) was applied.

At the initial assessment, a statistically significant difference was not determined only for the sit and reach test (r=.223). A statistically significant difference in favor of the CG was determined for the variable of the bent arm hang (r=.021). The statistically significant differences in the standing long jump (r=.023), sit-ups for 30 s (r=.023) and the 20 m run with a progressive increase in speed (r=.048) are all in favor of the experimental group, as indicators of its speed and agility (Tables 1 and 2).

Table 2 Descriptive indicators and differences at the univariate level among the participants at the final assessment

	Control group				Experimental group				ANOVA	
Variables	Mean	SD	Cv%	KS-p	Mean	SD	Cv%	KS-p	F	p
EFPS (cm)	17.32	6.20	35.77	.992	18.90	4.31	22.81	.498	2.191	.142
EFSD (cm)	146.36	28.57	19.52	.995	156.84	24.30	15.49	.968	3.904	**.050**
EFLS (reps.)	19.70	5.18	26.27	.912	22.88	6.42	28.06	.341	7.436	**.008**
EFZG (s)	32.00	22.59	70.61	.179	23.66	15.80	66.78	.403	4.575	**.035**
EFIZ (s)	185.24	43.43	23.45	.616	208.72	64.21	30.77	.915	4.587	**.035**

Legend: Mean – arithmetic mean value; SD – standard deviation; Cv% - coefficient of variation; KS-p – Kolmogorov-Smirnov test; F – value of F test; p – level of statistical significance

In the final assessment between the experimental and the CG, regardless of the better results of the EG, statistically significant differences were not observed for EFPS (r=.142) and the 10x5m (r=.131). In the case of variables pertaining to the tests of speed and agility, a statistically significant difference in the final assessment in favor of the CG was determined for the bent arm hang (r=.035). The EG achieved statistically significantly better results in the standing long jump (r=.050), sit-ups for 30 s (r=.008), the 4x10 test of speed, and agility at the 20m with progressive increase in speed (r=.035) (Table 2).

Table 3 Absolute and relative indicators of differences between the control and EG of participants related to the state of motor abilities at the initial and final assessment

	Control group				Experimental group			
Variables	Initial	Final	Abs	Rel%	Initial	Final	Abs	Rel%
EFPS (cm)	17.74	17.32	-0.42	-2.36	19.16	18.90	- 0.26	- 1.36
EFSD (cm)	143.21	146.36	3.15	2.20	156.36	156.84	0.48	0.31
EFLS (reps.)	18.36	19.70	1.34	7.30	21.20	22.88	1.68	7.92
EFZG (s)	33.00	32.00	- 1.00	- 3.03	22.05	23.66	1.66	7.30
EFIZ (s)	168.90	185.24	16.34	9.67	191.84	208.72	16.94	8.79

Legend: Initial - initial assessment; Final - final assessment; Abs - absolute values; Rel% - relative values

Table 3 shows the absolute and relative indicators of the difference between the control and EG in terms of the state of their motor skills at initial and final assessment. Absolute and relative values are positive for the standing long jump, sit-ups for 30 s and the 4 x10 test of speed, and agility at 20 m.

Regular PE classes led to positive effects in the CG for the variable of the standing long jump for absolute 3.15 cm, i.e., 2.20%, sit-ups for 30 s for absolute 1.34 repetitions, or 7.30%, and 4x10 test of speed and agility at 20 m for absolute 16.34 s, or 9.67%. Negative absolute and relative values are present in the variables of the sit and reach test (absolute value -0.42 cm, relative value -2.36%) and the bent arm hang (absolute value -1 s, relative value -3.03 %).

The obtained results of the EG show that the absolute and relative values are positive for all variables, except for the variability of the sit and reach test where the absolute values were reduced by 0.26 repetitions, or by 1.36%.

DISCUSSION

Comparing the achieved results with the results of elementary school children from other European countries, it is evident that the participants are below average in terms of the majority of tests that characterize the motor skills covered by the "Eurofit" battery. Based on previous studies, it can be concluded that girls of this age are more flexible than boys (Slater & Tiggemann, 2010; Pelemiš, Pelemiš, Mitrović, & Džinović-Kojić). At a younger school age, boys are more physically active than girls. According to Armstrong, Welsman, & Kirby (2000), Kerić, Rubin, Ujsasi, Fratrić, & Radulović (2017), the level of physical activity of boys does not decrease in this period, as is the case with girls.

During the onset of puberty, more girls than boys become inactive (Sollerhed, Apitzsch, Råstam, & Ejlertsson, 2008). In recent years, more and more research has focused on the monitoring of physical development and development of motor abilities in children in the context of official PE classes (Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006; Venetsanou & Kambas, 2010; Colella & Morano, 2011; Lemos, Avigo, & Barela, 2012). In the analysis of the development of motor abilities in children, the abilities are mainly associated with morphological characteristics, especially with the height and mass of the body. The focus of these studies is, in most cases, the influence of body height and mass (Benefice & Malina, 1996; Beunen et al., 1997; Stamenković, Bratić, Berić, & Pantelić, 2017) and the calendar age on the motor skills of children (Milde et al., 2006; Tomaszewski, Milde, Sienkiewicz Dianzenza, & Nowicki, 2007).

The results of previous studies show that the main factors for evaluating the efficacy of swimmers are unsuitable for students who are still learning to swim and that they differ considerably from one another in terms of motor skills (Formosa, Mason, & Burkett, 2011; Madureira, Bastos, Corrêa, Rogel, & Freudenheim, 2012). Similar results were obtained by individuals studying the effects of additional hours of physical activity on the improvement of motor skills of students (Boyle-Holmes et al., 2010; Matvienko & Ahrabi Fard, 2010; Ericsson, 2011). The abovementioned studies confirm the positive effects of additional physical activities on the transformation of motor skills of students, in comparison with the regular PE classes. Research in this area is primarily focused on swimming performance in relation to competitive distance (Tanaka, Costill, Thomas, Fink, & Widrick, 1993; Sutarto et al., 2010; Neiva, Marques, Barbosa, Izquierdo, & Marinho, 2014). The basic feature of the research is the modeling of top-quality swimmers (Smith, Norris, & Hogg, 2002; Okičić, Madić, Dopsaj, & Đorđević, 2007). As a result, it can be concluded that there is little research in the field of swimming training and that it can be one of the directions in swimming research and additional contents of teaching PE.

The obtained results in this research provide the arguments that students, in addition to their regular teaching PE classes, need to be introduced to additional PE classes, which would primarily meet the needs of students for physical activity and be a preventive measure for various types of diseases that occur due to obesity and insufficient activity. The swimming training program that has been realized will have long-term positive effects, not only because of the learned swimming techniques, but also because of the socialization of students who, through pleasant socializing during training, create a positive image of themselves and develop into complete and healthy personalities.

Increasing the number of PE classes in schools is an inevitable process, as it can be used to promote harmonious bio-psycho-social development in conditions of increasing hypokinesis. Due to positive action on the transformation of motor skills, swimming training should be the backbone of the PE system of preschool and school education.

In order to explain the importance of swimming to the students, it is also necessary to organize theoretical lectures where, with the help of multimedia presentations, students will be able to get to know swimming, jumping, and stroke techniques. By adopting this way of working, students would not only be provided with basic knowledge and skills in swimming, but also with the possibility for creative personal experiences both during theoretical classes and in practice for self-improvement and self-control. This kind of work would provide teachers and PE teachers with a more efficient organization of swimming training in the course of PE classes.

CONCLUSION

Theoretical research in the field of work with established programs and methods indicates positive results in swimming training, while practice shows that this mode of work has become stereotyped and governed by methodological uniformity. There is a need for the realization of swimming training, which will be modernized by new methods, and which will open new possibilities for thinking and introducing new approaches to previous stereotypes, with the necessary education of the teaching staff.

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UTICAJI NA REGULARNE NASTAVE FIZIČKOG VASPITANJA I NASTAVE SA DODATNIM VEŽBAMA NA MOTORIČKE SPOSOBNOSTI STUDENATA

Cilj istraživanja bio je da se uporede nastava fizičkog vaspitanja sa dodatnim treninzima plivanja i redovna nastava fizičkog vaspitanja i ispitaju uticaji na motoričke sposobnosti učenika mlađeg školskog uzrasta. Uzorak od 100 ispitanika podeljen je u dva subuzorka u odnosu na broj nedeljnih vežbi: subuzorak od 50 učenika (kontrolna grupa-KG) sa redovnom nastavom fizičkog vaspitanja i subuzorak od 50 učenika (eksperimentalna grupa-EG) koji su pored redovnih časova imali dodatno i dva treninga plivanja nedeljno. Program obuke kurseva plivanja sprovodio se tokom tri meseca prvog polugođa školske godine 2015/2016. U proceni motoričkih sposobnosti korišćeno je pet standardizovanih testova Eurofit baterije. Rezultati ukazuju na to da su dva treninga plivanja nedeljno uzrokovale statistički značajne razlike između EG i CG u trčanju na duge staze, trbušnjacima u trajanju od 30 s i trčanju na 20 m sa progresivnim prirastom u brzini. Rezultati ukazuju da plivanje pored već poznatog fiziološkog uticaja pozitivno utiče na transformaciju motoričkih sposobnosti kod učenika mlađeg školskog uzrasta.

Ključne reči*: fizičko vaspitanje, plivanje, motoričke veštine, učenici mlađeg školskog uzrasta*

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Research article

PHYSICAL FITNESS OF BOYS PERTAINING TO UNDERWEIGHT, OVERWEIGHT AND OBESITY

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Abstract. *Together with the changing socio-economic status of the Polish society, differences in the nutritional status of children and youth and their lower physical fitness levels are becoming more noticeable. The aim of this research was to define changes that occurred over a 10-year period regarding physical fitness of boys with proper weight-height proportions and of their underweight, overweight and obese counterparts. In 2004/05, somatic features and physical fitness were examined in 16116 and 9507 boys, respectively, aged 10-18. Ten years later somatic features and physical fitness assesmensts were repeated in 6972 and 6834 boys aged 10 to 18. The participants performed Eurofit tests and their body height and body mass were measured in order to calculate the Body Mass Index (BMI). The ten-year differences in physical fitness were expressed on a T point scale, while their extent was estimated with the Student's t-test for independent data. The frequency of occurrence of underweight and overweight was expressed in percentage values and verified with the use of the χ^2 test. In the analysed decade, an increase in the frequency of occurrence of both overweight and serious underweight was noted. It resulted in a lower level of physical fitness in children and youth belonging to the aforementioned groups. The most serious negative changes were noted in boys aged 13-15. It can be concluded that unless remedial programmes are implemented, the young generation will experience biological deterioration in the decades to come, which may result in an epidemic of lifestyle diseases in younger and younger individuals.*

Key words: *Physical Fitness, Boys, Body Mass Index, Eurofit Tests*

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INTRODUCTION

In numerous countries a continuous increase in the number of cases of overweight and obesity among children and youth is observed. At the same time the problem of insufficient body mass can be noted (UNICEF, World Health Organization-WHO & World Bank, 2020; WHO, 2020). This problem persists in economically developed countries but it also occurs in developing countries (Shirasawa et al., 2015; Forouzanfar et al. 2016; Hurbo, Skryhan, Radyhina, & Pamazanau, 2018). It has to be highlighted that these changes are not equal throughout the country, since regional differences can be noted (Lebel, Kestens, Clary, Bisset, & Subramanian, 2014; Abarca-Gómez et al., 2017; Akseer, Al-Gashm, Mehta, Mokdad, & Bhutta, 2017; Sandjaja et al., 2018). An increase in excessive body mass in children and youth exerts a negative influence on their physical activity (PA). This, in turn, results in lower levels of physical fitness (Katzmarzyk & et al., 2015; Tsiros et al., 2016). The aforementioned negative changes in height-weight proportions and lower levels of physical fitness also affect the development and health of children, youth and adults, which increases the risk of developing chronic non-infectious diseases (Kostić, Pantelić, Miletić, Uzunović, & Aleksandrović, 2012; Cvejić, Pejović, & Ostojić, 2013). In turn, an insufficient body mass may lead to lower stamina and performance levels, as well as a higher risk of bronchitis and pneumonia (Almirall, Bolibar, Balanzo, & Gonzalez, 1999; Dobner & Kaser, 2018; Van Nieuwpoort, Vlot, Schaap, Lips, & Drent, 2018).

After Poland had joined the European Union, faster socio-economic development was observed. It led, inter alia, to significant economic variability of its citizens, which, in turn, resulted in greater disproportions in the economic status of the Polish society. These processes differed depending on the region, which was also noticeable in the differences in the nutritional status of children and youth (Wolnicka, Jarosz, Jaczewska-Schuetz, & Taraszewska, 2016; Suder et al., 2020) and in their level of physical fitness (Przewęda & Dobosz, 2005; Dobosz, 2012). In the literature we can find numerous diagnoses of the biological state of children and youth. However, there is scarcity of data concerning the question whether the issue of lower physical fitness levels refers to all the observed children and whether it results from the changes in height-weight proportions.

The aim of this research was to define the changes that occurred over a 10-year period regarding physical fitness of boys with proper weight-height proportions and of their underweight, overweight and obese counterparts.

METHODS

Participants

Children from primary schools and youths from lower - and upper-secondary schools from Eastern Poland were initially examined in 2004/05. Taking into account the demographic structure of the regions, 220 schools were randomly selected from the list of educational facilities obtained from the Regional Educational Authorities. Particular attention was paid to maintaining equal population size in all the regions. The results of anthropometric measurements of 16116 boys aged 10-18 were obtained during 2004/05. The measurements were repeated in the same schools in 2014/15. This time a lower number of the anthropometric measurements were performed, i.e., the results of 6972 students aged 10-18 were obtained. Due to long-term PE exemptions and the lack of parental consent to perform

the test, PA was also assessed in a lower number of participants (N=6834) than in 2004/05 (N=9507).

Anthropometric measurements and physical fitness

The research was conducted in compliance with the guidelines included in the Declaration of Helsinki and was accepted by the Ethics Commission of the University of Physical Education in Warsaw.

Anthropometric measurements were performed in accordance with the broadly accepted anthropometric techniques recommended by the International Biological Program. On the basis of the measurements of body height and weight, the Body Mass Index (BMI-body mass in kilograms divided by height in meters squared) was calculated. Physical fitness was assessed on the basis of EUROFIT tests (Adam et al., 1998). According to the recommendations of the International Obesity Task Force and on the basis of border values provided by Cole, Bellizzi, Flegal, & Dietz (2000) and Cole, Flegal, Nicholls, & Jackson (2007), the participants were divided into groups. Group I included individuals of the 3rd-degree underweight, group II – those of the 2nd-degree underweight, group III – participants of the 1st-degree underweight, group IV – individuals with proper weight-height proportions, group V – overweight boys, and group VI – obese participants.

Statistical Analysis

The obtained populations made it possible to calculate the percentage of boys with underweight, overweight and obesity. Statistical significance of differences between the number of individuals qualified to each group and the total population examined in 2005 and 2015 was defined with the use of the χ^2 test. The material collected in 2005 underwent further statistical analysis including arithmetic means and distribution of results obtained in particular EUROFIT tests. Taking into account calendar age, the calculations were performed both for the whole material and in particular groups with different height-weight proportions. These values were used as reference points in comparative analyses revealing differences between the boys from schools in eastern Poland examined in two different periods. For this purpose, all the individual results of physical fitness tests from 2015 were compared with the results of boys from 2005 (50 points) with the use of T point scale (Furdal, 1989).

Such an analysis made it possible to standardise the units of fitness tests, while the mean from all the motor measurements in a group helped to assess general fitness defined as a statistical notion (Przewęda & Dobosz, 2005). Such calculations were performed for the whole material and within particular groups selected according to the BMI criterion. Taking this rule into account, the results of obese boys assessed in 2015 were compared to the results of obese participants examined in 2005. Similar analyses were performed in the remaining groups. Due to a low number of participants of the 1st- and 2nd-degree underweight, these groups were assessed together, which enabled us to draw conclusions for bigger groups. Next, arithmetic means and the distributions of point results for motor abilities were calculated both for the whole material and for particular groups divided according to the stages of education (10-12 years – primary school, 13-15 years – lower-secondary school, 16-18 years – upper-secondary school). Statistical significance of the differences between the results obtained in 2005 and 2015 was verified with the use of Student's t-test for independent data.

RESULTS

Prior to the analysis of the main aspect of the work, ten-year-long changes in the occurrence of underweight, proper height-weight proportions and overweight in the examined boys were determined. In the decade between 2005 and 2015 a significant decrease in the percentage of boys with proper BMI was noted (by 7.16%), while an increased percentage of 3rd-degree underweight (by 0.35%), overweight (by 5.04%) and obesity (by 1.91%) was observed in the whole examined population. Differences were slight in the group of participants of the 1st- and 2nd-degree underweight (table 1). However, in the group of boys aged 10-12, a significant decrease was noted in the percentage of all the boys with proper BMI (by 8.64%) and of the 1st-degree underweight (by 1.66%). In turn, the number of overweight and obese students increased (by 8.64% and 1.16%, respectively). Fewer significant differences were observed in boys aged 13-15. In this group a significant decrease in the percentage of participants with 2nd-degree underweight and a significant increase in the percentage of obese boys was noted (by 0.55% and 2.12%, respectively). In the group of the oldest participants, a significant increase was noted only in the number of obese boys (by 2.89%). In the remaining groups selected according to BMI, only tendencies could be observed.

Table 1 The percentage of participants in the groups of boys with proper BMI, underweight, overweight and obesity including stages of education

Age (years)	Year of research	3rd-degree underweight	2nd-degree underweight	1st-degree underweight	Proper BMI	Overweight	Obesity
10-12	2005	0.84	1.19	7.05	74.83	14.52	1.57
	2015	1.26	1.16	5.39	66.29	23.16	2.74
	χ^2 test	3.77	0.01	9.22*	13.45*	76.04*	14.07*
13-15	2005	0.59	1.21	5.2	75.25	16.64	1.11
	2015	0.84	0.66	4.55	74.79	15.93	3.23
	χ^2 test	1.09	3.89*	1.04	0.02	0.34	29.65*
16-18	2005	0.26	0.64	2.59	81.92	13.85	0.74
	2015	0	0.93	3.27	76.01	16.16	3.63
	χ^2 test	2.39	1.261	1.774	2.746	3.539	54.48*
10-18	2005	0.56	1.00	4.88	77.46	14.97	1.13
	2015	0.91	0.99	4.76	70.29	20.01	3.04
	χ^2 test	8.309*	0.002	0.143	19.23*	61.54*	92.30*

Legend: * statistical significance at the level of $p \leq 0.05$

In the decade discussed, a negative tendency of changes in physical fitness of the examined boys was also noted (table 3). In all the participants, a significant decrease was observed at the level of results of tests such as the flamingo balance (by 5.28 points), endurance shuttle run (by 4.69 points), standing broad jump (by 2.01 points), sit-and-reach (by 1.05 points) and the 10×5 m shuttle run (by 0.94 points). Similar results were noted in plate tapping and the bent arm hang. In turn, a significant improvement in the results of 30 s sit-ups (by 1.13 points) and the handgrip test (by 0.56 points) was revealed. On the basis of the mean obtained from all the tests, it was concluded that general fitness of the boys decreased by 1.39 points. A similar direction of changes but with a slight difference in the results was observed in the age groups (table 2).

Table 2 Physical fitness of boys (in T scale) from 2015 compared to the results from 2005 and statistical significance of differences (calculated with the Student's t-test) between the groups selected according to BMI and the total population

Physical fitness test	Total	Groups I and II	Group III	Group IV	Group V	Group VI
10-18 years						
Flamingo balance	44.72**	51.30	51.20	46.09**	38.30**	36.41**
Plate tapping	49.88	49.48	51.64*	49.80	50.04	48.24
Handgrip test	50.44*	50.27	49.50	50.47**	50.39	51.31
Standing broad jump	47.99**	49.87	47.01**	48.03**	48.30**	44.77**
Sit-ups	51.13**	48.67	50.57	51.39**	50.88	48.34
Bent arm hang	49.99	52.35*	52.11*	50.15	49.00	47.60*
Endurance shuttle run	45.31**	50.76	49.37	46.15**	41.49**	38.58**
10x5m shuttle run	49.06**	45.63**	48.27*	49.84	46.80**	46.82*
Sit-and-reach	48.95**	49.99	50.19	48.97**	48.55*	48.40
General fitness	48.61**	49.81	49.99	48.99**	47.08**	45.61**
10-12 years						
Flamingo balance	44.16**	50.86	50.71	45.56**	37.83**	35.79**
Plate tapping	50.29	49.09	51.62	50.19	50.72	48.52
Handgrip test	49.04**	50.73	48.13*	48.75**	49.65	52.75*
Standing broad jump	47.90**	49.45	46.48*	47.91**	48.55*	43.78**
Sit-ups	51.91**	49.73	50.39	52.14**	51.82**	51.27
Bent arm hang	50.05	53.25*	51.86*	49.80	49.94	51.64
Endurance shuttle run	43.21**	49.93	48.19*	44.23**	38.55**	35.28**
10x5m shuttle run	48.58**	45.11**	48.14*	49.18**	47.21**	46.60
Sit-and-reach	49.81	50.76	51.78*	49.78	49.6	47.58
General fitness	48.33**	49.88	49.70	48.62**	47.10**	45.91**
13-15 years						
Flamingo balance	45.87**	52.69	52.73	47.08**	39.42**	37.67**
Plate tapping	49.04**	50.69	51.73	49.08**	48.42	47.67
Handgrip test	51.03**	49.00	51.67	51.87**	48.07*	43.79**
Standing broad jump	47.59**	45.48	49.25	47.67**	47.06**	48.13
Sit-ups	48.75**	41.63**	49.46	49.24*	47.56**	44.56*
Bent arm hang	48.25**	47.69	54.29*	48.32**	47.44**	44.43*
Endurance shuttle run	47.94**	53.31	50.52	48.90**	43.50**	40.35**
10x5m shuttle run	47.71**	45.26*	48.76	48.61**	44.02**	44.36**
Sit-and-reach	47.60**	48.86	47.71	47.67**	46.73**	50.70
General fitness	48.20**	48.29	50.68	48.72**	45.80**	44.63**
16-18 years						
Flamingo balance	44.96**	51.78	51.72	46.32**	38.63**	36.73**
Plate tapping	49.64	49.89	51.67	49.63	49.57	48.10
Handgrip test	53.72**	49.41	53.10*	53.39**	55.66**	53.67
Standing broad jump	48.67**	60.89**	47.02	48.76**	48.87	44.37**
Sit-ups	51.63**	54.31	52.44	51.91**	51.45	45.28*
Bent arm hang	51.81**	54.76	51.00	53.19**	47.53**	42.00**
Endurance shuttle run	48.28**	51.78	53.17*	48.01**	49.40	43.73**
10x5m shuttle run	51.98**	49.90	48.37	53.03**	48.60	48.92
Sit-and-reach	48.06**	46.77	46.02**	48.36**	47.02**	48.41
General fitness	49.86	52.17	50.50	50.29	48.53	45.69*

Legend: * statistical significance set at the level of $p \leq 0.05$; ** statistical significance set at the level of $p \leq 0.01$

The above-mentioned tendencies of changes in the level of results of the EUROFIT tests do not provide information whether the direction of changes in all the groups selected according to BMI criteria was compliant with the trend noted for the whole population of boys from eastern Poland. It is also interesting which of the described groups demonstrated the largest and which the smallest changes in physical fitness over a ten-year period.

Based on general fitness results (table 3), it may be concluded that in the assessed decade the largest negative changes occurred in the boys with obesity (4.39 points), overweight (2.92 points) and those with a proper BMI (1.01 points). A similar secular trend was noted among 10-12-year-olds and 13-15-year-olds. In turn, in the oldest group of boys, lower physical fitness levels were noted only among obese boys. In the groups of underweight participants, no significant differences in the general fitness were noted. However, the differences were observed in the case of some tests only. As for the results of the participants from group I and II over a period from 2005 to 2015, a significant improvement in the bent arm hang (by 3.25 points) and a decrease in the 10x5 shuttle run (by 4.89 points) was noted. The boys from group III manifested positive changes in the bent arm hang results (by 2.11 points) and plate tapping (by 1.64 points), while negative changes were noted in the standing broad jump (by 2.99 points) and 10x5 shuttle run (by 1.63 points). It should be highlighted that in boys with a proper BMI the direction of changes in physical fitness was similar to that for the whole population. In turn, boys with overweight and obesity did not manifest an improvement in the results of any of the physical fitness tests. However, a deterioration of the results of overweight and obese boys was noted for the flamingo balance test (by 11.70 and 13.59 points, respectively), endurance shuttle run test (by 8.51 and 11.42 points, respectively), standing broad jump (by 1.70 and 5.23 points, respectively) and 10×5 shuttle run test (by 3.20 and 3.18 points, respectively). Moreover, overweight boys manifested lower results on the sit-and-reach test (by 1.45 points), while obese participants in the bent arm hang test (by 2.40 points).

DISCUSSION

The problem of the increasing number of overweight and obese people which was described at the beginning of this work, affected Poland as well. Currently, Polish youths, including students from Eastern Poland, are less overweight and obese compared to their counterparts from the majority of European Union countries (Saczuk, Olszewska, Wasiluk & Olszewski, 2011; Garrido-Miguel et al., 2019). However, the research of Charzewska (2012) revealed that the frequency of occurrence of obesity in Polish children and youth in the last 30 years increased approximately three times in boys and as much as ten times in girls. The author's observations revealed that 16.4% of school children and youth aged 7-18 were overweight and obese. The discussed developmental indices differed depending on the region. Our findings revealed a similar direction of changes in BMI. However, including eastern regions of the country in the group of regions with a low risk of overweight and obesity among children, as suggested by Wolnicka et al. (2016) is a debatable idea. In turn, the research by Wasiluk & Saczuk (2015) revealed that in the years 1985-2005, i.e. within two decades preceding the present observations, changes in the frequency of occurrence of overweight and obesity among boys aged 7-12 were at the level of 7.27% and 1.45%, respectively, and were lower than the differences noted in the decade between 2005 and

2015. A similar direction of changes was also noted in the selected age groups. Thus, it can be concluded that a delay in socio-economic transformations observed in eastern Poland also brings about a delay in negative biological changes in a young generation, while the pace of these changes increases together with an improvement in the socio-economic situation of the inhabitants of these regions.

However, it is distressing that an increase in the percentage of students with a significant underweight can be noted, which is not seen in the national or international research results. It may prove their malnutrition and it may result in bronchitis and pneumonia, asthma, an improper functioning of the digestive system and emotional distress (Gurzkowska et al., 2017; Yen, Shi, Soeung, Seng, Dy, & et al., 2018). Such changes may result from the lifestyle of children and youths, their diet and the economic situation of their families. Our observations can be confirmed by the research of Żądzińskiej et al. (2012) in which it was concluded that among children and adolescents aged 7-18 in Łódź within 26 years of the transformation (both economic and political), an increase in body mass deficiency in the years 1977/1978 and 2002/2004 was noted, in the group of boys from 7.2% to 12.1% and in the group of girls from 11.0% to 20.2%. Moreover, Gurzkowska et al. (2017) found that among socioeconomic determinants, only gross domestic product per inhabitant in the region to be a risk factor for thinness. It needs to be highlighted that Eastern Poland belongs to the group of less economically developed regions of Poland, and the issue of unemployment affects these regions to a large extent (Central Statistical Office, 2015). In order to confirm these observations, broader social research should be carried out.

The economic crisis from the 1970s and 1980s as well as socio-economic changes which have occurred in Poland since 1989 and their different pace in particular regions of the country influenced the size of secular trends in physical fitness. It was confirmed by national research (Przewęda & Dobosz, 2005), in which large sample groups in the years 1979-1989-1999 were compared. In the first analysed decade, a slight improvement in the results of fitness tests in the assessed girls and boys was noted, while the second decade saw a decrease in the scores. Another national study carried out in the years 1999-2009 proved a further decrease in physical fitness. The only exception was the handgrip test, in which an improvement in the results was noted (Dobosz, 2012). Similar changes in eastern Poland were observed by Saczuk (2011) in the years 1986-1996-2006. On the basis of the results described earlier, it may be concluded that the level of physical fitness decreases. However, bigger negative changes were noted in students aged 10-15, while slight changes were seen in boys aged 16-18.

What is particularly distressing is the fact that the largest negative changes concerning motor tests were noted in overweight and obese boys, while changes in the groups of boys with proper BMI were smaller. The greatest deterioration of results in the aforementioned groups was noted in running tests and lower limb strength. It is highly disturbing since these are groups of children who already manifested the lowest levels of physical fitness (Saczuk et al., 2011). Such significant differences were not found in the underweight participants; the only changes occurred in single fitness tests. It must be highlighted that the biggest negative changes in physical fitness occurred in the groups of these boys who also demonstrated the biggest negative changes in weight-height proportions.

The present generation of children may be the first one for a long time to have a shorter life expectancy than their parents. It may result from lifestyle diseases caused by improper diet and insufficient amount of PA. Another reason may also be the level of awareness of children and their parents and the form of physical education (PE) classes in schools. In

their report titled "Physical education and sport in state schools", the Supreme Audit Office negatively assessed the level of PE classes and sports facilities in the controlled schools (SAO, 2010). Apart from many other critical conclusions, the report also revealed that over 17% of primary school students, approximately 24% of lower-secondary school students and ca. 38% of upper-secondary school students did not participate in PE classes. As many as 74% of schools did not take any actions to prevent this phenomenon. The most common reason for PE exemptions included the lack of a sports outfit (33.10%), notes from parents (22.80%) and sick leaves (17.70%). However, many of the exemptions were not justified. Experts state that such exemptions should not be granted to children suffering from numerous diseases, e.g. spinal curvatures, asthma or diabetes. PA is one of the elements of treatment and should be taken up according to the doctor's recommendation. Thus, it is necessary to encourage the youth to take up PA and create appropriate conditions which would facilitate it. Moreover, interdepartmental remedial programmes aimed at improving the PA of children and youth should be prepared and implemented, with a particular focus on students with excessive body weight, as this group manifested the biggest negative changes in PA. The current actions of state administration are insufficient and focus generally on a particular group of girls and boys, mainly those with a proper BMI. These actions include only 30-40% of the whole population of children and youths (SAO, 2010), while the state of health of children is more and more alarming.

CONCLUSIONS

Taking into account the analysis of the changes in weight-height proportions and in the level of physical fitness of the assessed boys, an urgent need for interdepartmental remedial actions aimed at improving PA among children and youths was indicated, with a particular focus on students with excessive body mass. Unless remedial programmes are introduced, the young generation will experience biological deterioration in the years to come. We should expect a further increase in the number of overweight and obese people, a lower level of average motor abilities and performance capabilities, and, as a consequence, an epidemics of lifestyle diseases which will affect younger and younger individuals.

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FIZIČKI FITNES DEČAKA UZIMAJUĆI U OBZIR POTHRANJENOST, PREHRANJENOST I GOJAZNOST

Zajedno sa promenljivim socijalno-ekonomskim statusom Poljskog društva, razlike u nutritivnom stanju dece i omladine i njihovoj nižoj telesnoj spremnosti postaju sve vidljivije. Cilj ovog istraživanja bio je da se definišu promene koje su se dogodile tokom desetogodišnjeg perioda u pogledu fizičkog fitnesa dečaka sa pravilnim proporcijama telesne mase i visine, kao i njihovih vršnjaka sa prekomernom težinom, prekomernom težinom i gojaznim. U 2004/05. godine, ispitivana su somatska svojstva i fizička sprema kod 16116 i 9507 dečaka, uzrasta od 10-18 godina. Deset godina kasnije somatske karakteristike i procene fizičke kondicije ponovljene su kod 6972 i 6834 dečaka u uzrastu od 10 do 18 godina. Ispitanici su testirani Eurofit testovima i izmerena je njihova telesna visina i telesna masa u cilju izračunavanja indeksa telesne mase (prema engl. Body Mass Indeks-BMI). Desetogodišnje razlike u fizičkom fitnesu izražene su u T bodovnoj skali, dok je njihov opseg procenjen Studentovim t-testom za nezavisne uzorke. Učestalost pojave pothranjenosti I prehranjenosti izražena je procentualno i proverena pomoću χ^2 testa. U analiziranoj deceniji primećeno je povećanje učestalosti i prehranjenosti i ozbiljne pothranjenosti. To je rezultiralo nižim stepenom fizičke spremnosti dece i omladine kvalifikovanih za pomenute grupe. Najozbiljnije negativne promene primećene su kod dečaka uzrasta od 13 do 15 godina. Može se zaključiti da ukoliko se ne sprovedu sanacioni programi, mlada generacija će doživeti biološko propadanje u narednim decenijama, što može dovesti do epidemije oboljenja u mladih i mlađih pojedinaca.

Ključne reči*: fizička kondicija, dečaci, indeks telesne mase, eurofit testovi*

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Research article

PHYSICAL ACTIVITY AS ONE OF THE MOST OPTIMAL WAYS OF ACTIVE FATIGUE ELIMINATION AND OVERCOMING MIDLIFE CRISIS

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Abstract. *The main aim of this research is to investigate the relationship between the characteristic ways of overcoming the midlife crisis and the various ways of fatigue elimination. More precisely, to examine the correlation between denial by escape, denial by overcompensation, decompensation, and creative and successful coping with the crisis on the one hand and fatigue elimination with chemical stimulants, with psychological stimulation and with physical activity (PA) and active rest on the other, as well as the gender differences within these variables. The sample consisted of 300 middle-aged people, aged between 40 and 64, uniform by gender. The following instruments were used: A list of the respondents' basic biodata, the Midlife Crisis Scale and an evaluation scale representing the basic techniques of fatigue elimination in participants from different categories specifically designed for the research. Since the score distribution on the tested variables statistically deviate from normal distribution, non-parametric techniques were used. Pearson's correlation coefficient was applied for determining the connection between variables and the Mann Whitney U test for testing the difference between the groups of participants. The obtained results show that there is a statistically significant correlation between adequate PA, as a way of fatigue elimination, and the creative and successful coping with the crisis, as well as a moderate connection between different types of passive rest and decompensation, especially in women. It can be concluded that moderate, well-prescribed, and age-appropriate PA, as an important form of active rest, is connected with the most optimal way of coping with a midlife crisis.*

Key words: *Midlife Crisis, Adults, Physical Activity, Passive Rest, Fatigue*

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INTRODUCTION

Until recently, psychology has unjustly ignored an important and long period in the life and development of each individual, which is a period of maturity (Pavlović, 2014; Čolović, 2017).

Earlier, it was considered that the most important developmental changes occur during the first five years of life, that in the latency period few psychological and biological changes take place, and that puberty and adolescence are the last "psychologically important and interesting" periods of revival of previous, as well as new changes in the emotional, biological and social aspects (Milošević & Čolović, 2019).

The remainder of one's life was regarded as a relatively quiet period; however, with the work of eminent scholars and researchers and a more adequate perception of the everyday abilities, opportunities, needs and capacities of middle age people, it became clear that this period of life is certainly important and extremely rich in developmental changes. The current study points out and highlights the importance of physical activity (PA) as one of the adaptive and functional ways to adequately overcoming the normal developmental midlife crisis.

Increasingly, employed people can notice typical signs of fatigue, that manifest in the form of feeling exhaustion, lethargy, apathy, or irritability and mood swings (Čukić, 2003). Many of these psychological manifestations of fatigue are becoming an everyday routine for a large number of people and therefore represent a potentially serious problem for an individual and for their families, for which they do not have patience, energy and time. The appearance of fatigue is related to all, and therefore very different, human activities. In order to overcome fatigue, which in most cases transforms into a chronic condition, people in contemporary society employ very different strategies and ways of eliminating fatigue, some of which may be very dangerous for both physical and mental health.

PA and sports are considered as a completely natural and healthy way of eliminating fatigue, which, apart from the basic goal – fatigue elimination, will improve other spheres of human health and somatic and mental functioning (Chen, Chen, Martínez, Etnier, & Cheng, 2019).

All three of these dimensions can be classified into mechanisms of successful and creative overcoming of the midlife crisis in physically active individuals. The person is fully aware that he/she has used the first half of their life, does not fall into a depression and does not despair (which is characteristic of decompensation), does not even deny the process of aging and what is happening to him/her (which is characteristic of mechanisms of denial with escape and overcompensation). Such a person in spite of the awareness of age and death, finds new sources of satisfaction and the meaning of life, taking care that, by practicing and working on himself/herself increases the quality of their life (Vuori, 2005; Pavlović, 2014; Čolović 2017).

The main aim of this research is to investigate the relationship between the characteristic way of overcoming of a midlife crisis and the various ways of fatigue elimination. In order to do that, the correlation between denial by escape, denial by overcompensation, decompensation, and creative and successful coping with the crisis one the one hand and the fatigue elimination with chemical stimulants, with psychological stimulation and with a PA and the active rest on the other are examined, as well as the gender differences within these variables.

METHODS

The sample of participants

The study sample consisted of 300 middle-aged respondents, aged between 40 and 64 years, equally represented by gender. The sample was divided into two groups. The first group were those who daily (regularly) engage in some form of PA, while the second group were those who engage in some form of PA on an irregular basis (PA was not a part of their daily routine).

Measures

The following instruments were used: List of Basic Information on the Respondent, Midlife Crisis Scale-MCS (Pavlović, 2014), and an evaluation scale representing the basic techniques of fatigue elimination in respondents from different categories specifically designed for the research.

Data Analysis

Since the score distribution of the tested variables statistically deviates from the normal one, non-parametric techniques were used. To process the data, specific procedures for determining the normality of distribution of all variables in the scores of the respondents, Pearson's correlation coefficients for determining the correlation between variables and various procedures for testing the Mann-Whitney U test were used to determine the differences between males and females. The statistical analysis of the data was performed using the SPSS program for data analysis in social sciences.

RESULTS

In the following tables (Table 1 and Table 2) the results of the normality of distribution test of the respondents' scores are shown. It can be seen that the distribution of scores on all of the examined variables statistically significantly deviates from the normal one, while the magnitude of the given deviation is represented by the value of Kolmogorov-Smirnov test.

Table 1 Kolmogorov-Smirnov test for variables that indicate coping mechanisms of midlife crisis

	Creative dealing		Decompensation		Denial with escape		Denial with overcompensation	
	Statistic	Sig.	Statistic	Sig.	Statistic	Sig.	Statistic	Sig.
Score	0.074	.000	0.067	.000	0.045	.000	0.035	.000

Table 2 Kolmogorov-Smirnov test for variables that indicates different ways of fatigue elimination

	Chemical stimulants		Psychological stimulations		Physical activity		Passive rest	
	Statistic	Sig.	Statistic	Sig.	Statistic	Sig.	Statistic	Sig.
Score	0.098	.000	0.054	.000	0.079	.000	0.067	.000

Since the results of the Kolmogorov-Smirnov test for the distribution of scores in all of the examined variables showed that they do not have a normal distribution, non-parametric techniques were used in order to test the differences between genders.

The next step in the data analysis was to test the relationship between the two sets of variables, different types of midlife crisis coping mechanisms and different fatigue elimination techniques by means of Pearson's correlation coefficient.

Table 3 Relationship between different types of midlife crisis coping mechanisms and different fatigue elimination techniques

Coping mechanisms Of the midlife crisis		Different ways of the fatigue elimination			
		Chemical stimulants	Psychological stimulations	Physical activity	Passive rest
Creative and successful coping with	rho	.598		.832**	
	Sig.	.556		.000	
	N	300	300	300	300
Decompensation	rho				.537**
	Sig.				.000
	N	300	300	300	300
Denial with escape	rho				
	Sig.				
	N	300	300	300	300
Denial with overcompensation	rho				
	Sig.				
	N	300	300	300	300

Legend: ** The correlation is significant at the 0.001 level

It can be seen that there is a very high correlation between PA and creative and successful coping with the crisis (rho=0.832; p<0.001). That means that moderate, well-prescribed, and age-appropriate PA as an important form of active rest can help a person to deal with and overcome a midlife crisis in the most optimal way. It can, after a long day, invigorate and restore the body, giving it the necessary energy for new challenges and can contribute to the strengthening of confidence and feelings of self-worth among middle age persons.

It is also noticed that passive rest is statistically significantly connected with decompensation (rho=0.537; p<0.001). This may mean that passive rest in the form of lying down and avoiding any PA only exacerbates depression, amplifies the onset of negative thoughts, intensifies the fear of death, and a person descends into increasing despair.

As for the differences in terms of gender, the results showed that the scores of men and women from all age groups differ when it comes to eliminating fatigue with chemical stimulants and eliminating fatigue with active rest, while the differences in the third and fourth variable – elimination of fatigue with psychological stimulation and passive rest were not statistically significant (Table 4).

Table 4 Statistical significance of obtained differences

	Chemical stimulants	Psychological stimulations	Physical activity	Passive rest
Mann-Whitney U Test	23442.000	24387.000	21318.000	30023.000
Sig.	.000	.099	.000	.658

Legend: Group variable-Gender

Further, the Man-Whitney U test ranks for different ways of fatigue elimination in different genders showed that women often resort to certain chemical stimulants to eliminate signs of fatigue, while men more often use different types of active rest – PA (Table 5).

Table 5 Mann-Whitney U test ranks for different ways of fatigue elimination in different genders

Different ways of fatigue elimination	Gender	*N*	MR	∑R
Chemical stimulants	F	150	515.88	87878.00
	M	150	276.33	56142.00
	Total	300		
Psychological stimulations	F	150	316.54	98962.00
	M	150	284.46	87737.00
	Total	300		
Physical activity	F	150	386.99	61222.00
	M	150	542.78	91831.00
	Total	300		
Passive rest	F	150	294.31	77898.00
	M	150	358.32	99827.00
	Total	300		

As for the differences between men and women, when we take into account the possible ways of coping with and overcome a middle-age crisis, the only statistically significant difference was observed for the variables of decompensation (Table 6).

Table 6 Statistical significance of the obtained differences

	Creative coping	Decompensation	Denial with escape	Denial with overcompensation
Mann-Whitney U Test	23442.000	24387.000	21318.000	30023.000
Sig.	.359	.000	.486	.558

Legend: Group variable-Gender

Man-Whitney U test ranks for Basic manifestation of midlife crisis in different gender revealed that women expressed more decompensation than men.

Midlife is not necessarily a negative period in life for most people, but it does normally involve serious challenges which evoke changes in adaptive strategies. Women (MR=576.54) are more likely than men (MR=284.87) to, at the first hint of the crisis, react with a depressive mood, loss of interest in various things in life, increased concern about visible changes in their physical appearance and the fear of aging (Table 7).

Table 7 Mann-Whitney U test ranks for Basic manifestation of midlife crisis in different genders

Basic manifestation of the midlife crisis	Gender	*N*	MR	∑R
Creative coping with a crisis through physical activity	F	150	324.66	71992.00
	M	150	358.43	83108.00
	Total	300		
Decompensation	F	150	576.54	98962.00
	M	150	284.87	87737.00
	Total	300		
Denial with escape	F	150	435.98	88168.00
	M	150	399.01	98831.00
	Total	300		
Denial with overcompensation	F	150	356.31	87898.00
	M	150	359.32	92827.00
	Total	300		

DISCUSSION

There is no person in any modern society that did not experience one of the typical signs of fatigue: some form of exhaustion, lethargy, apathy, or irritability and mood swings (Schaffner, 2016). People in contemporary society try very different strategies and ways to eliminate fatigue, which in most cases transforms into a chronic condition, and some of these strategies may be very dangerous for both one's physical and mental health (Loades & Chalder, 2020). Fatigue can be eliminated in different ways. Some of them are quite healthy, natural and recommended (resting, psychological motivation), while others may have adverse effects (use of different types of hazardous chemicals - psychostimulants). Usually, there are three major groups of fatigue elimination strategies: Elimination of fatigue by chemical stimulants, Elimination of fatigue by psychological stimulation – motivation, and Elimination of fatigue by resting (active and passive rest).

By observing and summarizing all of these facts it can be said that active people of all ages have fewer health problems than those who usually sit. Playing sports or light PA, like walking and light exercise has a very positive impact on one's health, somatic as well as psychological (Calfas & Taylor, 1994; Fox, 1999; Goran & Treuth, 2001; Ströhle, 2009; Bherer, Erickson, & Liu-Ambrose, 2013; Cvejić & Ostojić, 2017; Mitraković et al., 2016), but also represents one of the most important and the best ways to rest, provides the fastest recovery of the tired body, enabling the energy to continue working (Kim, Kim, Newman, Ferris, & Perrewé, 2019).

Considering the main aim of this research, the investigation of the relationship between the characteristic ways of overcoming a midlife crisis and the various ways of fatigue elimination, the results of Pearson's correlation coefficients indicated a very high correlation between PA and creative and successful coping with the crisis ($rho=0.832$; $p<0.001$). These findings suggest that PA in middle-aged persons might be a positive associating factor to mental health outcomes, and are congruent with previous research on middle-aged women and men (Brown, Ford, Burton, Marshall, & Dobson, 2005; Elavsky & McAuley, 2007; Sörensen et al., 2008; Liu, Li, Li, & Zhang, 2017). The significant correlation between passive rest and decompensation ($rho=0.537$; $p<0.001$) is a clear indication that passive rest

(or physical inactivity) exacerbates depression, amplifies the rumination of negative thoughts and a person's descent into increasing despair.

Further findings of the current study confirmed statistically significant differences between participants of different genders when it comes to the basic techniques of eliminating fatigue. Results indicate that women often resort to certain chemical stimulants to eliminate signs of fatigue, while men rather use different types of active rest – PA. In a view of the differences in the technique of the fatigue elimination with active rest by gender, they are consistent with findings from previous studies where it generally was found that men more frequently use active rest or PA than women (Frändin, Mellström, Sundh & Grimby, 1995; DiPietro, 1996; Livingstone, Robson, McCarthy, & Kiely, 2001; Rhodes, Janssen, Bredin, Warburton, & Bauman, 2017).

If we consider a life crisis as a form of stress, it is a fact that there is a growing literature on the positive aspects of stress, sometimes called "the perceived benefits of stress" (Aldwin & Sutton, 1998; Čolović, 2017). While coping may mitigate the effects of stress, being able to perceive and act upon it may result in positive long-term effects. These positive changes may include material gain, changes in perspective, stronger social bonds, increased coping skills, mastery and self-esteem, increased self-knowledge, and perhaps wisdom as well (Aldwin, 1994). This allows a person to be involved in many activities within the community, enjoy hobbies, find a new balance within themselves, and crown their life with new purpose and meaning, that is, in Marmor's terms, to creatively and successfully face a crisis (Pavlović & Zlatanović, 2012).

CONCLUSION

The normal development of an individual, and therefore the aging process as its inevitable and integral component, cannot be stopped or prevented no matter how one seeks it and strives to achieve it. With age, our skin begins to lose elasticity, becomes loose, wrinkly, our hair becomes grey, women enter menopause. These physical changes on the face and body can pose serious narcissistic harm for persons who are in the middle and late period of life, especially in cultures that cherishes the cult of youth and beauty, as ours does.

Moderate, well-prescribed, age-appropriate PA is an important form of active rest, that after a long day invigorates and restores the body, giving it the necessary energy for new challenges, which can also alleviate the signs of aging and contribute to the strengthening of self-esteem and feelings of personal values in middle-aged persons. Such PA enables a person to become more active and to explore inner potentials and revive new or long forgotten interests.

Based on the results from the current study it can be concluded that PA in any form (from walking to the intense training and practicing certain sports) is an important basis of health, both physical as well as psychological.

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FIZIČKA AKTIVNOST I AKTIVNO ELIMINISANJE ZAMORA KAO JEDAN OD NAJOPTIMALNIJIH NAČINA PREVAZILAŽENJA KRIZE SREDNJIH GODINA

Osnovni cilj ovog istraživanja bio je da se ispita povezanost između karakterističnih načina prevazilaženja krize srednjih godina i različitih načina otklanjanja umora. Preciznije, da se ispitaju korelacije između poricanja sa bekstvom, poricanja sa natkompenzacijom, dekompenzacijom i kreativno suočavanje sa krizom sa jedne strane, i otklanjanja zamora hemijskim stimulatorima, psihološkom stimulacijom, putem fizičke aktivnosti i aktivnog odmora, kao i razlike po polu u okviru ovih pokazatelja. Uzorak ispitanika činilo je 300 ispitanika srednjih godina, između 40 i 64 godine ujednačen po polu. Primenjeni su sledeći instrumenti: Skala krize srednjih godina-SKSG i za potrebe ovog istraživanja konstruisana skala za procenu osnovnih tehnika za otklanjanje umora ispitanika različitih grupa. S obzirom da su pokazatelji ditribucije ukazali na statistički značajno odstupanje od normalne distribucije, primenjene su neparametrijske statističke procedure. Primenjen je Pirsonov koeficijent korelacije u cilju određivanja povezanosti između varijabli, a Mann Whitney U test za testiranje razlika između ispitivanih grupa. Dobijeni rezultati pokazali su da postoje statistički značajne korelacije između adekvatne fizičke aktivnosti kao načina za otklanjanje umora i kreativnog suočavanja sa krizom, kao i umerene korelacije između različitih oblika pasivnog odmora i dekompenzacije, posebno kod žena. Može da se zaključi da je umerena, pravilno dozirana i uzrasno odgovarajuća fizička aktivnost kao važan oblik aktivnog odmora povezana sa sa najoptimalnijim načinom suočavanja sa krizom srednjih godina.

Ključne reči: *kriza srednjih godina, odrasli, fizička aktivnost, pasivni odmor, zamor*

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Research article

THE IMPACT OF SPORT GAMES EXERCISE PROGRAMS ON THE DEVELOPMENT OF SPECIFIC MOTOR ABILITIES IN ADOLESCENTS WITH INTELLECTUAL IMPAIRMENT

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Abstract. *The aim of this study was to determine the effects of a sports games experimental program on improving specific motor abilities in adolescents with mental impairment. The study was conducted on a sample of 60 adolescents diagnosed with mild mental impairment, divided into two groups (experimental group EG, and control group CG) with an equal number of participants. The special program of sports games lasted for 12 weeks, with a weekly frequency of four times and a duration of 30 minutes per training. The participants of both groups were tested with the same variables within the specific motor skills for the sport of football and basketball. After a twelve-week experimental program of sports games, there were statistically significant improvements in the EG in the variables: SMFS, SMDR, SMCP with a statistical significance of r=0.000. The results of the ANOVA and MANOVA analyses indicated that after the application of the specific sports games program there was a statistically significant difference in the benefits for the EG compared to the CG, in the parameters of specific motor abilities with a statistical significance r=0.000 and the size of the impact. Based on these research results, it can be concluded that a specific exercise program conducted within twelve-week training of specifically dosed sports activities has significantly contributed the development of specific motor skills for football and basketball.*

Key words: *Football, Basketball, Mild Mental Impairment, Adolescents*

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INTRODUCTION

According to the latest research, the population of people with disabilities worldwide is about 10%, which is about 800 million people (Popović, 2015). This group of people include persons with physical disabilities, persons with sensory disabilities and persons with intellectual disabilities or mental impairment (Đurašković & Živković, 2009). There are between 120 to 200 million people with intellectual disabilities worldwide (American Association on Mental Retardation, 1992). Such data indicate the necessary seriousness in organizing and implementing, above all, systemic support for their life and work.

Mental retardation defines the condition of an impaired or underdeveloped mind, which can be seen through a characteristic impairment of the abilities that contribute to the development of intelligence: motor skills, speech, thinking and socializing. According to this definition there are levels of mental impairment that are determined by the intelligence coefficient. Those are light mental impairment (intelligence coefficient from 50 to 70), persons developed at the level of a 7 to a 12 year-old, mild mental impairment (intelligence coefficient from 35 to 49), persons developed at the level of a 4 to a 7 year-old, hard mental impairment (intelligence coefficient from 20 to 34), persons developed at the level of a 2 to a 4 year-old, difficult mental impairment (intelligence coefficient below 20), persons developed at the level of a 2 year-old (WHO, 1992; Szymanski & King, 1999; King, Hodapp, & Dykens, 2000; Not, 2008).

People with diagnosed intellectual impairment are persons, in the broadest sense, who are not fully able to comply with all the social norms of an average person. There are many definitions of this impairment (WHO, 1992; American Association on Mental Retardation, 1992; Szymanski & King, 1999).

The physical activity (PA) of this population, and generally people with disabilities nowadays is no longer a taboo, and is rapidly developing and improving in accordance with the needs of certain disability groups (Đurašković & Živković, 2009). People with diagnosed mental impairment are people whose muscular functionality is preserved, and who have no limitation in the movement amplitudes. However, due to weaker motor skills, their movements, especially more complex movements, are very difficult, i.e., they have no slope of movements during performance. This problem is more pronounced with a smaller intelligence coefficient (King et al., 2000; Not, 2008). Because of this, these persons were from the very beginning of their life, their school age, ignored by persons without disabilities, which emphasized their malaise in the social environment, reducing their desire to take an active part in any kind of PA (Radivojević & Raičević, 2007). The results of all this were quantified by various studies that dealt with the discovery of the differences between the population diagnosed by mental impairment and the one without it (Graham & Reid, 2000).

Great differences in physical capacities, fitness components (cardiorespiratory and cardiovascular), as well as in body composition, are present between people with and without disabilities, in favor of people without disabilities. For these reasons, today's environment in which people with diagnosed mental impairment live is an organized system adapted to their personal needs, enabling them to develop their potentials. Today, people with disabilities can be physically active through specialized primary and secondary education, in terms of physical skills through sports associations together with their friends with the same or similar levels of mental impairment (Stanišić, 2013; Popović, 2015). An organized aspect of PA through sports content at international levels is organized within the so-called Special Olympics (Đurašković & Živković, 2009). At such organized sports gatherings, these people, depending on the level

of their intellectual abilities, i.e., their coefficient of intelligence, are classified and they compete in various individual and collective sports, with rules adapted to their abilities (Đurašković & Živković, 2009).

Sports games as organized physical activities represent a very important factor especially in the developmental period of life, adolescence. The maximum utilization of the physical, motor skills, potentials of the person contributes to the preservation and improvement of their health, as well as to the improvement of the quality of their lives. It also affects the development of social components and social integration (Podgorski, Kessler, & Cacia, 2004; Cowley et al., 2010). Football and basketball as some of the basic collective ball games, with the highest popularity in the world, provide the opportunity to meet all the motor skill needs for people with diagnosed disabilities due to the presence of the following elements: jumping, throwing, running, shooting.

The significance of these sports games is due to a specific organized educational system (Radenković, Berić, & Kocić, 2014) adapted to this population of people within the hours of physical education organized in the period of intense growth and bodily development, i.e., adolescence (Stanišić, 2013; Popović, 2015). However, the implementation and organization of lectures is not directly classified and adapted to the appropriate levels of mental impairment. Persons diagnosed with mild mental impairment whose level of intelligence ranges from 50 to 70 represent a group of people who, with the help of adequate methods and realization of physical education classes that are time-modified (for a duration of 30 minutes) would be more beneficial than physical education classes for a duration of 45 minutes, which are beneficial for persons without any disabilities (Stanišić, Berić, Bojić, Nurkić, & Kocić, 2012; Stanišić, Kocić, Aleksandrović, Stanković, & Radovanović, 2012).

Pursuant to this, special programs of sports games, focused only on the level of mild mental impairment, provide the possibility of developing specific motor skills potential.

Adolescents diagnosed with mental impairment represent a population of children who are different from adolescents who are not diagnosed with mental impairment, firstly at the cognitive characteristics level. Due to the marginalization of this population of people and their very frequent rejection by the environment (due to the increased ability limitation), adolescents with this disability are less physically active and less motivated to deal with any kind of PA. This certainly affects the difference in the level of fitness components; increased levels of fat, that is, obesity is more common with children not diagnosed with mental impairment (Maksimović, 2012).

In terms of motor skills, persons diagnosed with mental impairment have poorer results in almost all motor skills. This difference is specifically expressed in movement coordination (which is considered to be motor intelligence) and whose development and ability can greatly improve the manifestation of other basic and motor skills (Chaiwanichsiri, Sanguanrungsirikul, & Suwannakul, 2000; Guideti, Franciosi, Gallota, Emeranziani, & Baldari, 2010; Iveković, 2013).

Specific motor skills are skills that are related to the performance of a movement, element or exercise in sports activities, which combines two or more basic and motor skills, thereby affecting an increased limitation in performance (Stojiljković, 2003, 114). However, people diagnosed with mild mental impairment (70 to 50) have abilities like children aged 9 to 12 who are not diagnosed with intellectual disability (King et al., 2000; Not, 2008).

Adolescents with mild mental impairment while engaging in PA within sports games have to pay more attention, i.e., they need more repetition and more time to master the technical

elements (Golubović, Maksimović, Golubović, & Glumbić, 2012). There are also very many unnecessary movements in more complex elements, or in the course of expressing specific motor movements (Hartman, Houwen, Scherder, & Visscher, 2010; Golubović et al., 2012).

Having in mind the above mentioned, the aim of this study is to determine the effects of a special exercise program on the development of specific motor abilities in sports games in adolescents with diagnosed mental impairment.

METHODS

Sample of participants

The study included 60 participants diagnosed with light mental impairment. The participants were adolescents aged 13 to 17 attending higher elementary school grades (grades 5 to 8) in the "14. October" elementary school from Niš and the "11 October" secondary school from Leskovac.

The participants were divided into two groups of 30 members each. The adolescents diagnosed with mild mental impairment: the experimental group (EG) had four hours of a special program of sports games aimed at developing motor skills; the control group (CG) had three regular physical education classes and one more lesson of physical education of the chosen sport prescribed by the plan and program of the Ministry of Education, Science and Technological Development of the Republic of Serbia.

Due to the fact that the participants were underage, their guardians consented in providing permission for them to participate in this research.

Sample of measuring instruments

In the testing of specific motor skills for basketball, the assessment was carried out through four elements: running the ball (SMRB in points), catching the ball (SMCB in points), passing the ball (SMAB in points), and shooting at the basket (SMSB in points). The test battery that was used had been used in previous studies of this population (Guidetti, Franciosi, Emerenziani, Gallotta, & Baldari, 2009; Stanišić et al., 2012a). To assess the specific motor abilities of the participants, adolescents with diagnosed light mental impairment, specific motor tests for football and basketball were used. Within the framework of specific motor tests for football, assessment tests of three elements were used: shooting at the goal (SMSG in points), dribbling (SMDR in points), controlling and passing the ball (SMCP in points). This group of tests for the assessment of specific motor skills was also applied in the research of Popović (2015). This test was designed to consist of four levels, classified by the weight of the performance of each of these elements, and each level contains five different tasks within each element. Each task carries a maximum of one point if it is successfully done, half a point if the attempt was not properly performed, but there were also zero points if the participant did not attempt to perform the task at all. Each task carries a maximum of one point, each element within a single level carries five points, and each level makes a total of 20 points. If the participant did not achieve a minimum of 15 points within one level, he could not move on to the second level of complexity required to perform elements.

Experimental program

The expressive program of sports games lasted for 12 weeks with a weekly frequency of four times a week for 30 minutes. During that time, the participants mastered the technical elements for football (leading the ball, shooting at the goal and passing the ball) and basketball (leading the ball, catching the ball, passing the ball and shooting at the basket) during the main part of the lesson. During each lesson, the participants performed two or more elements by ten repetitions for a warm-up and for raising the muscle tonus that should be activated during the main part of the lesson. The last five minutes were reserved for muscle relaxation and body preparation for further school activities.

Statistical data processing

Data processing was performed by the SPSS statistics program (v17.0, SPSS Inc., Chicago, IL, USA).

All data were presented descriptively, while in order to determine statistically significant differences at the univariate level, a t-test for independent samples was used.

In order to determine whether there are differences, but primarily which variables contribute to the difference at the final measurement between the EG and CG the most, a canonical descriptive analysis was used.

A multivariate analysis of variance (MANOVA) was used to determine the differences within groups for different measurements. The differences for each measuring instrument or variable were determined by a univariate analysis of variance (ANOVA).

In order to determine the effects of a special sports games program, the neutralization of the differences at the initial measurement between the groups was performed using MANCOVA (a multivariate analysis of covariance) and ANCOVA (a univariate analysis of covariance).

RESULTS

Table 1 Specific motor abilities: T-test comparison between the EG and the CG at the initial measurement

Variables (in points)	Mean EG	Mean CG	Mean Diff (EG-CG)	t	df	p	Cohen's d
SMRB	10.18	8.97	1.22	0.98	58	0.33	0.14
SMCB	9.02	9.15	-0.13	-0.11	58	0.91	-0.02
SMAB	7.98	8.27	-0.28	-0.23	58	0.82	-0.03
SMSB	6.77	7.20	-0.43	-0.36	58	0.72	-0.05
SMSG	75.67	72.67	3.00	0.48	58	0.63	0.09
SMDR	43.00	38.67	4.33	1.01	58	0.31	0.18
SMCP	49.00	52.67	-3.67	-0.74	58	0.46	-0.13

Legend: Mean EG – average value of the results of the experimental group; Mean CG – average value of the results of the control group; Mean Diff (EG-CG) – differences gained when subtracting the arithmetical mean of the experimental group and the arithmetical mean of the control group; t – calculated value of the t-test; df – degree of freedom; p – statistical significance of the t -test Cohen's d – calculating the Cohen`s indicator of the difference size

The results shown in table 1 describe the differences between the EG and the CG at the initial measurement within the variables that describe the specific motor space. Based on these results, it can be noticed that there are no statistically significant differences between the EG and the CG at the initial measurement within the specific motor variables.

Table 2 Specific motor abilities: T-test comparison between the EG and CG at the final measurement

Variables (in points)	Mean EG	Mean CG	Mean Diff (EG-CG)	t	df	p	Cohen's d
SMRB	10.90	8.85	2.05	1.64	58.00	0.11	0.24*
SMCB	9.90	8.72	1.18	0.98	58.00	0.33	0.14
SMAB	8.87	7.95	0.92	0.73	58.00	0.47	0.10
SMSB	7.63	6.82	0.82	0.69	58.00	0.49	0.10
SMSG	87.67	64.33	23.33	3.62	58.00	0.00**	0.65**
SMDR	50.33	33.33	17.00	3.82	58.00	0.00**	0.68**
SMCP	59.33	43.00	16.33	3.57	58.00	0.00**	0.64**

Legend: Mean EG – average value of the results of the experimental group; Mean CG – average value of the results of the control group; Mean Diff (EG-CG) – differences gained when subtracting the arithmetical mean of the experimental group and the arithmetical mean of the control group; t – calculated value of the t-test; df – degree of freedom; p – statistical significance of the t -test Cohen's d – calculating the Cohen`s indicator of the difference size

Based on the results presented in table 2, which describes the differences between the EG and the CG at the final measurement within the variables of the specific motor space, it can be seen that there is a difference between the EG and CG. This difference can be noticed in the SMFS variable, and is in favor of the EG with a statistical significance of the test (r=0.00) and Cohen's size indicator d (0.65). Differences were also observed in the MGLR variable in favor of the EG with a statistical significance of the test (r=0.00) and Cohen's size indicator d (0.68**), in SMCP in favor of the EG with a statistical significance of the test (r=0.00) and Cohen's size indicator (0.64**). In the other variables at the final measurement within the specific motor skills between the EG and the CG, there were no statistically significant differences.

Table 3 Significance of an isolated discriminatory function

Eigen	Canonical R	Wilks' L.	Chi-sqr.	df	p
0.650	0.628	0.606	27.279	7	0.000**

Legend: Eigen – square of the determination coefficient, Canonical R – canonic correlation coefficient, Wilk's L – Wilk's lambda test, Chi-Sqr – Bartlett's X_2 test, df – degree of freedom, p – degree of significance

Table 3 shows the results of an isolated discriminatory function. A statistically significant difference can be noticed at the level of 0.01 (p = 0.000) between the EG and the CG at the final measurement in the specific motor space. A canonical discriminatory analysis has shown that there is one significant discriminatory function, which is very high and explained with 63% (Canonical R = 0.628). It shows that the correlation of the data set, based on the way the discriminatory analysis was carried out, is significant and high. The discriminative strength of the variables expressed through the Wilk's L test (0.606) indicates that the function discriminates the participants correctly. Also, based on the isolated discriminative

function, it can be seen that the high separation power of these two samples is significant, and this function is significant, since the probability of error is equal to 0. This indicates that the EG and the CG statistically and significantly differ in the part of specific motor skills.

Table 4 Correlations of variables with a discriminative function

	Function1
SMDR	0.622
SMSG	0.590
SMCP	0.582
SMRB	0.267
SMCB	0.159
SMAB	0.118
SMSB	0.113

Function 1 – isolated discriminative function

The results in table 4 indicate the correlation of variables with a discriminative function. The essential difference between the EG and the CG in the specific motor functions is in the variables MGLR (0.622), SMFS (0.590), SMCP (0.582), and significantly less in the other variables.

Table 5 Discriminant function coefficients

	Function 1
SMRB	3.456
SMCB	-1.137
SMAB	-1.552
SMSB	-0.906
SMSG	0.370
SMDR	0.340
SMCP	0.198

Function 1 – isolated discriminative function

Table 5 shows the results of the coefficients of a descriptive function, which indicate that the EG at the final measurement is specifically better in the variables of SMRB (3.456), SMCB (-1.137), SMAB (-1.552) and SMSB (-0.906).

Table 6 Group centroids

	Function 1
EG	0.792
CG	-0.792

EG – experimental group; CG – control group

Table 6 presents the results of the analysis of the group centroids, which represent the arithmetic means between the EG and the CG. The results indicate their high discrimination ranging from 0.792 for the EG and -0.792 for the control group of participants.

Table 7 Precision of the a posterior classification

Group	Percentage	EG	CG
EG	73.3	22	8
CG	76.7	7	23
Total	75.0	30	30

EG – experimental group; CG – control group

The results in table 7 represent the efficacy of separating the EG and the CG at the final measurement in the variables for basic motor ability assessment. The percentages show that the discrimination was made with a precision of 75%. It can be seen that 22 participants belong to the EG, and 8 the control group, while 23 participants from the control group belong to their own group, and 7 belong to the opposite group.

Table 8 Multivariate analysis of covariance of specific motor abilities between the experimental and the control group at the final measurement

Wilks' Lambda	F	df1	df2	p	Partial Eta Squared
0.142	38.843	7	45	0.000**	0.858

Legend: Wilk's Lambda – Wilk`s Lambda test; F – F approximation; df – degree of freedom; p – significant statistical differences * < 0.05. ** < 0.0; Partial Eta Squared – influence size

Table 8 shows the results of the multivariate analysis of covariance of the applied variables for the assessment of specific motor abilities between the EG and the CG at the final measurement, neutralizing the recorded differences at the initial measurement. Based on the obtained results, it can be concluded that there is a statistically significant difference at the multivariate level between the EG and the CG, at the significance level of 0.01 (p-level=0.000). The recorded difference occurs under the influence of the applied experimental program, and it can be concluded that it affects the transformation of specific motor abilities in the experimental group.

Table 9 Univariant analysis of covariance of specific motor abilities between the EG and the CG at the final measurement.

Variables (in points)	Adj. Mean EG	Adj. Mean CG	Adj. Mean diff.(EG-CG)	F	p	Partial Eta Squared
SMRB	10.19	9.56	0.63	9.03	0.004**	0.15***
SMCB	9.71	8.90	0.81	14.99	0.000**	0.23***
SMAB	8.90	7.92	0.99	14.95	0.000**	0.23***
SMSB	7.80	6.65	1.15	23.97	0.000**	0.32***
SMSG	88.93	63.07	25.86	83.80	0.000**	0.62***
SMDR	48.27	35.40	12.87	80.50	0.000**	0.61***
SMCP	61.76	40.57	21.19	54.78	0.000**	0.52***

Legend: Adj. Mean – corrected arithmetic mean (E – experimental group, K – control group); Adj. Mean diff. – differences between the corrected arithmetic means; F – Φ test; p – degree of significance , statistically significant difference ** < 0,01 * < 0,05; Partial Eta Squared – size of influence (small*, medium**, high***)

The results in table 9 show the univariate difference in the variables for the assessment of specific motor abilities between the EG and the CG at the final measurement with the neutralization and partialization of the results at the initial measurement. A statistically significant difference in all variables of this area was determined at the level of significance r=0.01.

DISCUSSION

A special program of sports games is a program within which the participants of the EG mastered and performed the elements of football and basketball. These sports games were an instrument used to influence the development of specific motor skills of the adolescent participants diagnosed with light mental impairment. The results of the initial descriptive statistics proved to be an extremely heterogeneous set of variables for the EG, and also the heterogeneity data were similar to the control group. In accordance with the obtained results from the initial measurement in the factor of heterogeneity, the variables of the specific motor space were also obtained in previous studies (Stanišić et al., 2012a; Stanišić, 2013).

By comparing the results of the initial measurement between the EG and the CG in the variables of specific motor skills, in football and basketball, we did not find significant statistical differences. The obtained results indicate the same starting points in the specific motor skill of the respondents in both sports games, i.e., the participants had similar previous experiences and skills.

The results of the descriptive statistics at the final measurement within the variables describing the condition of the specific motor space of the EG who took part in a special sports games program show an increase in the results. The mean values of the variables determined by the specific motor skills within the game of football increased in all variables: SMFS (Final Measurement Mean=87.67; SD=24.45; Initial Measurement Mean=75.67; SD=23.88), SMDR (Final Measurement Mean=50.33; SD=16.61; Initial Measurement Mean=43.00; SD=16.66), SMCP (Final Measurement Mean=59.33; SD=19.11; Initial Measurement Mean=49.00; SD=20.23). The obtained results within the descriptive statistics indicate the positive impact of a specific exercise program in the variables of football. Also, the results of the mean values of the variables or tests determining the specific motor abilities after the application of the specific basketball exercise program resulted in an increase in mean values: SMRB (Final Measurement Mean=10.90; SD=5.33; Initial Measurement Mean=10.18; SD=5.17), SMCB (Final Measurement Mean=9.90; SD=5.03; Initial Measurement Mean=9.02; SD=4.68), SMAB (Final Measurement Mean=8.87; SD=5.10; Initial Measurement Mean=7.98; SD=4.89), SMSB (Final Measurement Mean=7.63; SD=4.47; Initial Measurement Mean=6.77; SD=4.29).

Positive changes in the results of the descriptive statistics within the mean values indicate that a specific program of sports games with a duration of 12 weeks was beneficial i.e. appropriate. By comparing these results with the results of previous researchers or their research, one can notice the positive statistical contribution of the program with quantum higher values and with a reduction in the duration and the frequency of training (Franciosi, Guidetti, Gallotta, Emerenzian, and & Baldari, 2010; Stanišić, 2013). Also, due to quantified data representations, it can be noticed that there has been a quantum increase in the mean values in the final measurement results in variables that were evaluated for specific motor

skills within the game of football. The explanation of these results can be noticed by the specificity of the tests, i.e. by their complexity and the manner of quantifying the skills displayed, but also by the popularization of the game.

For the control group of participants who did not take part in the special sports games program, but who had regular physical education classes prescribed by the plan and program of the Ministry of Education, Science and Technological Development of the Republic of Serbia, the results of descriptive statistics have shown that within the variables that were used to evaluate specific motor skills in the game of football, a slight decrease in the mean values was noted: SMFS (Final Measurement Mean=64.33; SD=25.42; Initial Measurement Mean=72.67; SD=24.06), SMDR (Final Measurement Mean=33.33; SD=17.88; Initial Measurement Mean=38.47; SD=18.2 4), SMCP (Final Measurement Mean=43; SD=16.22; Initial Measurement Mean=52.67; SD=17.99). Also, the results in the variables evaluating the specific motor skills in basketball showed a slight decrease in mean values: SMRB (Final Measurement Mean=8.85; SD=4.31; Initial Measurement Mean=8.97; SD=4.44), SMCB (final measurement Mean=8.72; SD=4.32; Initial Measurement Mean=9.15; SD=4.55), SMAB (Final Measurement Mean=7.95; SD=4.65; Initial Measurement Mean=8.27; SD=4.70), SMSB (final measurement Mean=6.82; SD=4.65; Initial Measurement Mean=7.20; SD=4.90).

Analyzing the results and comparing or noting the existence of differences in the variables of the specific motor skills for football and basketball at the initial measurement between the EG and the CG showed no statistically significant difference in any variables. In accordance with the results, it can be concluded that the existence of knowledge and skills of the participants of both groups was equal. The level of knowledge and skills related to specific motor variables indicate very similar starting points that were a very important parameter for rendering the program's relevance more visible, or obtaining more accurate post-treatment results.

The results of the final measurement of both groups of participants calculated by the t-test, which was performed to detect quantifiable differences in the results of specific motor abilities in football and basketball, showed the existence of statistical differences in favor of the EG. A statistically significant high difference was first of all seen in all variables of the specific motor skills for football ($p = 0.00$). In the variables for the specific motor skills for basketball, the results of the t-test did not show a statistically significant difference. The size of the differences in variables were shown as statistically significantly different (Cohen's d), as the size of the difference was very high. Pursuant to the obtained values, it can be pointed out that football has provided a greater increase in the test results evaluated against basketball, whose results were quantifiably higher than the initial results, but did not have a statistically significant difference as determined by the t-test. However, a slight difference was confirmed by Cohen's d test, and Cohen's indicator of the size of the difference, which established a very low existence of differences.

The canonical descriptive analysis at the final measurement of the variables that indicate the level of the state of the specific motor skills within the game of football and basketball has identified qualitative differences. Differences determined by this statistical analysis showed very high values, i.e. statistical significance ($r=0.001$). Also, the results which indicate a correlation of variables with a discriminative function indicate an extremely large difference in the variables that determine specific motor skills within the game of football. However, the coefficients of the discriminant function show significant

improvement and variables that determine the state of specific motor skills in the game of basketball. The results obtained thus in the final measurement indicate that the specific program of sports games for a duration of 12 weeks, with a frequency of four times a week and lasting 30 minutes per training, is sufficient to improve the state of specific motor skills statistically and significantly. Similar studies have also shown an increase in the results in the specific motor space of people with mental impairment (Guidetti et al., 2009; Franciosi, Guidetti, Gallotta, Emerenziani, & Baldari, 2010; Stanišić, 2013).

The statistical procedures of the ANCOVA and MANCOVA analyses that were applied in the area of specific motor abilities of the participants confirmed the quantitative and qualitative results obtained by descriptive parameters as well as the t-test and canonical correlation analysis. The results of these analyses determined a statistically significant effect on the EG diagnosed with light mental impairment at the adolescent age in all variables used to describe the condition of a specific motor space, with a significance level r=0.000. The size of the impact for each individual variable (Partial Eta Squared) was large. The results obtained after the application of this program indicate the quality of the program itself as well as the benefits of the program in accordance with the sample of participants in terms of age characteristics and their abilities. It was easy to see the results of the applied special program for sports games, and the instruments used to determine the specific motor skills that were used in previous studies (Guidetti et al., 2009; Franciosi et al., 2010; Giagazoglou, Arabatzi, Dipla, Liga, & Kellis, 2012; Blomqvist, Olsson, Wallin, Wester, & Rehn, 2013; Stanišić, 2013). Also, the research published in the previous ten years suggests that a 12 to 20-week exercise program with a frequency of three to four times a week with a duration of 30 to 40 minutes is sufficient to allow changes in the specific motor skills for the mentioned sports games.

The comprehensiveness of the development of both the basic motor space and the specific motor space within the sport games of football and basketball for adolescent participants diagnosed light mental impairment of both sexes indicates that a specific and specially designed program of sports games was in accordance with the tendencies of solving the research problem. Based on this, it was concluded that the objectives and hypotheses of the research are consistent with the results achieved and are fully accepted.

CONCLUSION

The twelve-week training program led to statistically significant high changes in specific motor skills in all the variables related to football, as well as in the variables related to basketball, especially in ball control activities. In other variables, envisaged by this research, there is a statistically significant improvement, but with a lower degree of significance.

The results of the current study indicate that a specific exercise program conducted as part of a 12-week training with specifically dosed sports activities has significantly contributed to the development of specific motor skills in the games of football and basketball.

The findings from this research can be of great importance for the development of appropriate models of programs for the development of the abilities of specific motor skills for adolescents diagnosed light mental impairment. It is in the adolescent period,

when the body is ready to endure the biggest changes during its development, the advantages of this program should be used in the best possible way.

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EFEKTI SPECIJALNOG PROGRAMA VEŽBANJA NA RAZVOJ SPECIFIČNO MOTORIČKIH SPOSOBNOSTI U SPORTSKIM IGRAMA KOD ADOLESCENATA SA MENTALNOM RETARDACIJOM

Cilj ovog istraživanja bio je da se utvrde efekti eksperimentalnog programa sportskih igara na poboljšanje specifično motoričkih sposobnosti adolescenata sa mentalnom retardacijom. Istraživanje je sprovedeno na uzorku od 60 ispitanika adolescenata sa dijagnostikovanom lakom mentalnom retardacijom podeljenih u dve grupe, sa jednakim brojem ispitanika. Specijalni program sportskih igara trajao je 12 nedelja, sa nedeljnom učestalošću od četiri puta i dužinom trajanja jedne trenažne jedinice od 30 min. Ispitanici obe grupe su testirani istim varijablama u okviru specifično motoričkih sposobnosti u okviru sportske igre fudbal i sportske igre košarka. Nakon dvanestonedeljnog eksperimentalnog programa sportskih igara došlo je do statistički značajnih poboljšanja kod eksperimentalne grupe u varijablama: SMSG, SMDR, SMCP sa statističkom značajnošću r=0.000. Rezultati ANOVA i MANOVA analiza su ukazali da nakon primene specifičnog programa sportskih igara postoji statistički značajna pozitivna razlika u korist eksperimnetalne grupe u odnosu na kontrolnu grupu u parametrima specifično motoričkih sposobnosti sa statističkom značajnošću r=0.000 i veličinom uticaja. Na osnovu ovakvih rezultata istraživanja može se zaključiti da specifični program vežbanja sproveden u okviru dvanaestonedeljnih časova specijalno doziranih sportskih aktivnosti je značajno doprineo razvoju specifično motoričkih sposobnosti u okviru sportke igre fudbala i košarke.

Ključne reči: *fudbal, košarka, laka mentalna retardacija, adolescenti*

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Research article

BODY HEIGHT AND LORDOTIC POSTURE IN PRESCHOOL CHILDREN

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Abstract. *The aim of this research is to determine the relation between body height and lordotic posture in preschool children. The survey was conducted on a sample of 149 participants (78 boys and 71 girls), aged 6 years (± 6 months), of an average body height (BH) of 121.94±10.29 cm, and the body mass 23.20±4.83kg in the city of Kragujevac (Serbia). To assess lordotic posture, the Spinal Mouse was used, and all values above 30˚ were treated as disorders in the lumbar region. In determining the size of the body, the Anthropometer by Martin is used, and the participants were divided into five groups by height. The existence and size of the correlation between the investigated areas was calculated by the use of the Pearson's chi-squared test and contingency coefficient as a measure of correlation. From the total sample, lortodic posture is present in 8.05 % of the participants, and in terms of gender the incidence of poor posture is equal. Lordotic posture is most pronounced in the group of boys and girls with the BH of 123.01-127.00 cm, followed by the group of girls with a BH of 121.51-123.00 cm. The lowest incidence of lordotic posture is determined in the groups with BH over 127.01 cm, and below 119 cm. The values of the Pearson's chi-squared test indicate a statistically significant correlation between lordotic posture and body height, with a significance 0.03.*

Key words: *Body Height, Lordotic Poor Posture, Incidence, Correlation, Preschool Children*

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INTRODUCTION

Lumbar lordosis refers to an adaptation that ensures stability in humans when standing and walking (Wren et al., 2017). The habit of paying attention to whether children adopt correct body position in everyday life is lacking (Kot, Kokosz, & Stencel-Gabriel, 2018), and as a consequence there is an increased incidence in lower back pain (Sadler, Spink, Ho, De Jonge, & Chuter, 2017), and sleeping disorders (Lauridsen & Hestbaek, 2013). By correcting the position of the body and placing the lumbar part in a neutral position, back pain can be reduced (Smith, O'Sullivan, & Straker, 2008). Hence, poor postural status represents a growing, but still underestimated health problem that needs preventive and accurate diagnosis (Jorgić et al., 2016).

In lumbar lordosis the aligned position of the pelvis is compromised by the unequal contracting forces of the abdominal and hamstring muscles that should normally be in balance with each other (Jang, Koh, & Han, 2013). Physical factors with the highest odds for lower back pain are a higher lumbar lordotic apex and an increased pelvis retroversion (Dolphens et al., 2016). According to Mulhearn & George (1999) lumbar hyperlordosis is associated with the dysfunction of the transversus abdominis muscle. According to Malai, Pichaiyongwongdee, & Sakulsriprasert (2015), hold-relax stretching of the iliopsoas muscle can be beneficial in reducing pain intensity, lumbar hyperlordosis and in improving the function of the transversus abdominis muscle in patients with excessive lumbar lordosis.

The sedentary lifestyle of today's adolescents consisting of a low level of physical activity, and a high level of computer oriented mental activities has reached epidemic proportions. Computer technology offers the young population a lot of entertainment and information resources, so that they spend more time in the so-called passive positions (sitting and lying). Such habits are distancing them from the natural need for movement and significantly reduce most of their physical and functional abilities. In a word, the children of today are playing in the fresh air less and are less physically active.

In terms of the above-mentioned the aim of this research is to determine the relation between body height and lordotic posture in preschool children.

METHODS

The research was conducted on a sample of 149 pre-schools children (78 boys and 71 girls), aged 6 years (±6 months) of the city of Kragujevac (Serbia), with an average body height of 121.94±10.29 cm (Mean±SD), and an average mass of 23.20±4.83 kg (Mean±SD). For the assessment of lordotic posture, non-invasive measurement methodology provided by the Spinal Mouse device was used (Idiag, Fehraltdorf, Switzerland, www.idiag.ch). The validity and reliability of the Spinal Mouse device are confirmed in previous studies (Mannion, Knecht, Balaban, Dvorak, & Grob, 2004; Post & Leferink, 2004; Forster, 2006; Guermazi et al., 2006).

Lumbar angulation in the sagittal plane was evaluated in a standing position. In order to classify the level of the disorder by category, the values determined by Cobb were used. Angulation of 15-30˚ is considered normal, and all values above 30˚ are treated as disorders in the lumbar region.

Body height is determined according to the methodology recommended by the International Biological Program (Weiner & Lourie, 1969), and with usage of the Anthropometer by Martin.

Children were divided into the following five groups according to body height (BH): 1) less than 119.00 cm; 2) between 119.01-121.50 cm; 3) between 121.51-123.00 cm; 4) between 123.01-127.00 cm, and 5) more than 127.01 cm.

Standard descriptive parameters (mean, minimum score, maximum score, standard deviation) were used. Pearson's chi-squared test (H^2) with a significance level of the correlation set at $p \leq 0.05$ was calculated by using the statistical package for data analysis SPSS, version 12.

RESULTS

Descriptive parameters of the postural status in relation to gender, as well as values of Pearson's chi-squared test, the contingency coefficient and the significance are presented in Table 1.

Table 1 Lordotic posture in relation to gender

Postural status		Gender		Total
		Boys	Girls	
Good posture	Count	72	65	137
	%	92.31	91.55	
	% of Total	48.32	43.62	91.95
Lordotic posture (the deviation is larger than 30°)	Count	4	6	10
	%	5.13	8.45	
	% of Total	2.68	4.03	6.71
Lordotic posture (the deviation is larger than 40°)	Count	2	0	2
	%	2.56	0	
	% of Total	1.34	0	1.34
Total	Count	78	71	149
	% of Total	52.35	47.65	100

Legend: Pearson's chi-squared test 2.43; Contingency coefficient 0.13; Significance p=0.30.

Of the total sample of participants, lordotic posture was present in 8.05% of the participants, and the incidence of poor posture by gender was uniform.

The values of Pearson's chi-squared test (2.43) and the contingency coefficient (0.13) show an absence of statistically significance between lordotic posture and gender in the participants, with a significance of 0.30.

Descriptive parameters of the postural status in relation to gender and body height groups, as well as the values of Pearson's chi-squared test, the contingency coefficient and the significance are presented in Table 2.

Observed in terms of the BH groups of participants, lordotic posture is most frequent in the group of BH 123.01-127.00 cm, followed by the group of girls of BH 121.51-123.00 cm. The lowest incidence of poor posture was determined in the group of participants of BH of more than 127.01 cm, as well as in the group of BH of less than 119 cm.

Concerning the lordotic posture of the boys, the largest incidence is determined in the group of BH 123.01-127.00 cm and the group of participants with BH of over 127.01 cm. In the other BH groups, there were no cases of scoliotic posture. In the sample of girls, lordotic posture is most frequent in the group of BH 121.51-123.00 cm, and the group of

BH 123.01-127.00 cm. There were no cases of the scoliotic posture at all in the groups of BH up to 119.00 cm and BH over 127.01 cm.

Table 2 Body height and lordotic posture in relation to gender

		Lordotic posture					
		Good posture		Deviation is larger than 30°		Deviation is larger than 40°	
Body height		Boys	Girls	Boys	Girls	Boys	Girls
	Count	14	20	0	0	0	0
≤ 119.00 cm	%	19.44	30.77	0	0	0	0
	% of Total	17.95	28.17	0	0	0	0
	Count	16	10	0	1	2	0
119.01-121.50 cm	%	22.22	15.38	0	16.67	100	0
	% of Total	20.51	14.08	0	1.41	2.56	0
	Count	13	14	0	3	0	0
123.01-127.00 cm	%	18.06	21.54	0	50	0	0
	% of Total	16.67	19.72	0	4.23	0	0
	Count	14	10	3	2	0	0
≥ 127.01 cm	%	19.44	15.38	75	33.33	0	0
	% of Total	17.95	14.08	3.85	2.82	0	0
	Count	15	11	1	0	0	0
≥ 127.01 cm	%	20.83	16.92	25	0	0	0
	% of Total	19.23	15.49	1.28	0	0	0
Total	Count	72	65	4	6	2	0
	%	92.31	91.55	5.13	8.45	2.56	0

Legend: Boys: Pearson's Chi-Squared Test 14.59; Contingency coefficient 0.40; Significance p=0.07; Girls: Pearson's Chi-Squared Test 5.77; Contingency coefficient 0.25; Significance p=0.22

The values of Pearson's chi-squared test of 14.59 in boys and of 5.77 in girls, as well as the contingency coefficient of 0.40 in boys and 0.25 in girls, with a significance of 0.07 in boys and 0.22 in girls, indicate the absence of a statistically significant difference between BH and lordotic posture of participants observed in terms of gender and height groups.

DISCUSSION

The juvenile period (ages 4 to 7) is a critical period in the growth and development when deformities such lordotic posture are formed (Protić-Gava, Krsmanović, Jevtić, Kadović, & Romanov 2009).

Proper posture is evident in a decreasing number of children (Đokić & Stojanović, 2010; Ludwig, Mazet, Mazet, Hammes & Schmitt, 2016). The analysis of all obtained results shows the appearance of lordotic posture associated with body height (Bogdanović & Milenković, 2008; Bogdanović & Marković, 2009; Trajković & Nikolić, 2008). The results obtained in our research do not have statistical significance, but show a tendency of lordotic posture with increasing height. Petrović, Puzović, Đorđević, Obrenović and Jakovljević (2012) conclude that hyperlordosis is present in 9.2% of cases, and that gender and age do not significantly affect the prevalence of this deformity.

The shift in the results of the spinal column parameters depending on the age category can be explained by the fact that the reduction of physical activity of children with the beginning of preschool and school obligations leads to a muscle imbalance which is directly related to spinal deformity and lordosis. Improper and long sitting in front of the TV, the computer, improper carrying of a school backpack, are also reasons for the development of spinal deformities, as well as hunched standing. In order to create an equilibrium position, there is a compensatory movement of the pelvis that leans forward, which leads to an increase in lumbar lordosis. These movements can also lead to the development of other spinal deformities (Andrašić, Milić, Cvetković, Ujsasi, & Orlić, 2017).

The research of other authors, local and foreign, indicate similar tendencies between BH and certain postural disorders, both in the preschool population and later in adolescence.

According to the results of Protić-Gava et al. (2013) on a total sample of 61 participants, aged 8.52 years, lordotic posture prevailed as the most common in: 41% of children was with minor deviations and 13.1% with larger deviations. Similar results, in a population of children aged 6 to 7 were found by Romanov, Stupar, Međedović, and Brkin (2014): the most common was lordotic posture, 41.31% in male participants and 36.66% in female participants. Gh, Alilou, Ghafurinia, & Fereydounnia (2012) point out that the prevalence of lordosis is 22.6% among children aged 5 to 20. Lordosis increases by 6° from the age of 5 to 15 (Widhe, 2001).

Simov, Minić and Stojanović (2011) determined the manifestation of the lordotic posture in 2.07% of preschool children.

Korovljev, Marinković, Roška, and Madić (2015) point out that spinal deformities significantly increase and appear in children of a younger school age compared to preschool children, emphasizing the negative effect of the significantly heavier school bags than recommended (10% of the total weight of the child).

CONCLUSION

The results obtained in this research, observed on the total sample, indicate that lordotic posture was most expressed in the group of boys and girls of BH 123.01-127.00 cm, followed by the group of girls of BH 121.51-123.00 cm. Special attention is required in the prevention, i.e., in the adequate education of the staff of preschool institutions.

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VISINA TELA I LORDOTIČNO LOŠE DRŽANJE DECE PREDŠKOLSKOG UZRASTA

Cilj ovog istraživanja je da se utvrdi odnos između visine tela i lordotično lošeg držanja dece predškolskog uzrasta. Istraživanje je sprovedeno na uzorku od 149 ispitanika (78 dečaka i 71 devojčica), uzrasta 6 godina (±6 meseci), prosečne telesne visine (BH) 121.94±10.29 cm i telesne mase 23.20±4.83 kg, grada Kragujevca (Srbija). U proceni lordotičnog lošeg držanja korišćen je uređaj Spinal Mouse, a sve vrednosti iznad 30° tretirane su kao poremećaji u lumbalnom delu kičmenog stuba. Za utvrđivanje visine tela korišćen je Antropometer po Martinu, a ispitanici su prema visini podeljeni u pet grupa. Postojanje i veličina korelacije između ispitivanih područja izračunati su korišćenjem Pearsonovog Hi kvadrat testa i koeficijenta kontingencije kao mere korelacije. Od ukupnog uzorka, lortodično držanje je zastupljeno u 8.05% ispitanika, a u odnosu na pol, incidenca lordotično lošeg držanja je jednaka. Lortodično loše držanje je najizraženije u grupi dečaka i devojčica BH 123.01-127.00 cm, a sledi grupa devojčica BH 121.51-123.00 cm visine. Najniža incidenca lordotičnog lošeg držanja utvrđena je u grupama BH preko 127.01 cm i ispod 119 cm. Vrednosti Pearsonovog Hi kvadrata testa pokazuju statistički značajnu povezanost između lordotično lošeg držanja i BH, sa nivoom značajnosti od 003.

Ključne reči: *telesna visina, lordotično loše držanje, učestalost, korelacija, predškolska deca*

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