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Narrative review article

MOTOR AND INTELLECTUAL DEVELOPMENT IN CHILDREN: A REVIEW

UDC 796.012.1:165.19-053.5

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Abstract. *The aim of this narrative review article is to present the effects of physical activity on the motor and cognitive development of children. Early childhood is one of the most critical periods in a child's physical and intellectual development. As much as seventy percent of the brain's connections develop during the pre-school years, these connections form the basis and framework for the child's later abilities and characteristics. A physically stimulating and varied environment undoubtedly has a significant impact on the mental functions of children. The brain is designed to learn and solve problems, initially simple, later complex. The earliest challenges that the brain needs to solve are related to movement. Children solve these problems spontaneously, intuitively, and in an unstructured manner. Later, with more organized movements, children acquire various motor skills, abilities, and sensory experiences, thereby gaining a new understanding of themselves and their surroundings. These insights and experiences will equip the child for the challenges and problems they will face later in life. Children enter into social interactions and group dynamics through movement and acquire a sense of autonomy and independence. A stimulating and varied motor environment undoubtedly has a significant impact on children's intellectual function and, thus, on the development of their potential abilities.*

Key words: *Motor Development, Cognitive Development, Physical Activity, Children*

INTRODUCTION

Children have a biological need to move. The World Health Organization (2004) recommends that children and adolescents are physically active for 60 to 90 minutes a day. However, this is often not the case. Modern consumer-oriented lifestyles, fun electronic and communication products have caused a devastating movement deficit in young people. Children spend a lot of their time in the virtual world in front of computers, tablets, and

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other "wonders" of the modern world. The consequences are obvious and evident in many fields. The SLOfit project (Slovenian National System for Monitoring the Physical and Motor Development of Children and Youth), a longitudinal study conducted by the Faculty of Sports, University of Ljubljana, showed that we have more and more overweight children in Slovenia. Compared to other countries of the European Union, Slovenian children and adolescents fall into the critical group of those with increased body weight. In 2015/2016, it was established that about 20% of boys aged 10 to 13 and about 18% of girls in the same age category were overweight (Starc, Strel, Kovač, Leskošek, Sorić, & Jurak, 2016). As a result, children are less physically fit than decades ago, especially in various motor skills. Our teenagers (11-14 year olds) run 600 m 8 seconds slower than their counterparts of 40 years ago (Škof & Tvan, 2016). The aerobic 600 m run is one indicator of a child's general motor efficiency and functional ability, especially pertaining to the vascular and respiratory systems. Slovenian children's physical efficiency is declining, the portion of less physically competent children is increasing, and their number has doubled in the past twenty years (Strel, Jurak, Starc, & Strel, 2016; Starc et al., 2016).

Childhood health is often correlated with being overweight and having a lower level of motor skills. Lack of physical activity (PA), an unhealthy diet, and poor physical fitness directly jeopardize children's health. Today, heart disease, metabolic diseases, and type 2 diabetes pose serious health, paediatric, and social problems for Slovenian children (Škof, 2016). Why are physical activities the right choice for kids? Because they not only strengthen muscles, the heart, and lungs, but they also present opportunities for peer collaboration, biological development, intellectual, psycho-social, and mental development on which happiness and satisfaction of children are based. Physically less successful and less physically active children also have lower academic achievements than more physically able and active children (Strel et al., 2016). Physical - sports activities help young people develop into creative individuals with core values. Children and adolescents who are physically active create significant health capital for adulthood. Regular PA in youth encourages greater care for a healthy lifestyle later in life.

The aim of the research is to determine the effects of the PA on the motor and cognitive development of the children.

THEORETICAL CONSIDERATIONS OF THE PROBLEM

Recently, there have been many new insights related to the mental development of children. Scientific discoveries in neuroscience, neurophysiology, cognitive psychology, kinesiology, and modern paediatrics show new aspects of the development of children's potential. The development of human biological potential is a complex and dynamic process that requires the systematic cooperation of several factors, among which the individual, genetic, family, and social environments play a decisive role (Renzulli, 1986; Hannon, 2003). For brain development, the pre-school period is crucial in the dynamics of this process. The human brain is the result of its evolution; it is the organ that enables us to survive. The only constant of the brain is its ability to change and adapt to its given circumstances. Humans are the product of millions of years of adaptation to natural and social environments. While our ancestors lived on cliffs, collecting food and hunting animals, running was a necessary part of their lives. The brain was a "luxury" organ that required a lot of energy, and this needed to be ensured by providing it with enough food

to keep the brain functioning optimally. Scientists have found (Lieberman, 2015) that it was running in those prehistoric times that enabled our ancestors' brain development because they were more successful at finding food by running. Brain development depended primarily on the increased amount of protein that humans could obtain by hunting and eating animals. The only "weapon" that Homo erectus had was fast legs. With a larger brain, they could generate more knowledge, more complex cognitive and social behaviours, including speech and collaboration (Lieberman, 2015). As such, their development into more successful hunters and gatherers gave them a much better chance of survival. Smarter hunters and gatherers were able to interact better with each other, create more significant energy surpluses. In subsequent evolutionary periods, the brain evolved through natural selection. The "running gene" is still present in humans today, and this is especially evident in children (Eynon et al., 2013).

The brain is a gelatinous organ hidden within the skull, whose function is so complex that many aspects still cannot be explained. The average human brain weighs 1,400 grams, accounting for about 2% of the average human body weight. However, it consumes as much as 20% of all the oxygen available to our body (Bregant, 2011). A new-born's brain weighs about 300 grams, which is 10% of their body weight. Recent neuroscientific research shows that 50% of intelligence is hereditary, and one's environment influences the rest. We have approximately 100 billion nerve cells (neurons) in the brain that communicate with each other through connections (synapses). At birth, each neuron in the cerebral cortex has about 2,500 synapses, with the number increasing to 15,000 within the first two years of life (Bregant, 2011). An infant's brain consumes around 100 calories per day, which is 60% of their daily resting energy expenditure. The adult brain consumes between 280 and 420 calories per day, which is 20 to 30% of a person's daily resting energy expenditure (Lieberman, 2015).

During the first month of life, the total number of the brain's synapses increases from 50 trillion to 1 quadrillion (Bregant, 2010). Synapses are a dynamic system; they are formed, strengthened, or even lost if not properly stimulated. This phenomenon is called "brain neuroplasticity". The synapses we use more often are preserved, the ones we use less disappear (Bregant, 2012; Bregant, 2011).

The brain is in constant functional change; it is like a "construction site". We strengthen it through training, we weaken it with non-training. Synapses - connections can become thicker, thinner, or deteriorate altogether. According to some research, the critical period of intellectual development happens in early childhood from 2 to 5 years of age. More than 70% of synapses develop in this pre-school period. Research shows that an individual's intellectual abilities depend not only on the number of nerve cells but also on the number of synapses (Volpe, 2008; Rajović, 2016a). Maturation and development of the brain - synapses are formed most intensively up to the fifth year (50%), up to the seventh year (70%), and up to the twelfth year of life (95%). Brain development is thus most intense in the first few years of life when neurons combine into neural networks of interconnections. Inside the brain, there is a constant struggle for dominance in which new connections are created between active neurons (nerve cells). Inactive neurons die, and inactive neural pathways are lost forever.

The number of connections between neurons increases through activity, which is reflected in the density of the neural network within the brain. How do we stimulate neural functioning and connection formation? A child's brain is a highly absorbent "sponge" that receives various stimuli from its surroundings. In early childhood, the child

processes information about the image, sound, and feel of an object as a whole (Rajović, 2016b). As a child begins to perceive his or her surroundings, new connections between nerve cells begin to establish. The more stimulating the environment a child lives in, the greater the number of created synaptic connections. During the first years of life, the basics of thinking, language, sight, hearing, taste, and physical skills are developed. A child receives many visual, auditory, tactile, and motor stimuli from the environment through innate primary ontogenetic motor skills such as crawling and climbing (Malina, Bouchard, & Bar-Or, 2004; Videmšek & Pišot, 2007; Pišot, 2012). For humans, learning is a life-long process, but the foundations are formed in early childhood. The child is an explorer.

Due to the high brain plasticity in early childhood, susceptibility to environmental factors and lifestyle is significant in growing and developing children (Rajović, Berić, Bratić, Živković, & Stojiljković, 2016).

A stimulating environment allows for the development of synapses and denser neural networks, which form the basis for mental development later on. From a multitude of sounds, a child uses only those they hear in the environment. The most common, and simultaneously one of the most difficult mental challenges for a child is their mother's voice. Between the second and third years of age, the child can already recognize colours and symbols. The importance and effects of early childhood activity can be seen by studying certain cultures with exceptional abilities. Eskimos can distinguish between fifteen shades of white from the age of five. This ability is related to their observation of ice and snow. The Maori people are known to be extremely musical. Mothers sing songs to their children during pregnancy and later into childhood. Music and dancing are said to run in the blood of the Romani people.

The importance of elementary PA for the overall development of children

The first problems the brain needs to solve are related to movement. The child must find a suitable motor solution for reaching a toy through a developed perception of their own body. These are the initial cognitive processes associated with movement. The brain is created to learn and solve problems, initially simple, later complex (Gardner, 1995; Epstein, 2015, Bregant, 2011). The child solves these problems spontaneously, intuitively, and in an unstructured manner. Later, with more organized movement, the child acquires various motor skills and sensory experiences, thus creating a new understanding of itself and its surroundings. These insights and experiences will equip the child to better deal with the challenges and problems life brings. Through movement, children also enter into mutual interactions, group dynamics, and acquire a sense of autonomy and independence.

The basic human characteristics are walking upright and the ability to speak, which evolutionarily separate us from other animals. Man is otherwise a rather helpless mammal. While a foal or fawn can walk immediately after birth, it takes a human baby a year or more to learn to walk. PA is not only good from a health perspective but also for academic achievement. If a child spends a lot of time being passive, sitting, or lying down, there is a high possibility of developing cognitive problems later on. Each hour of sitting should be replaced by two hours of play or other PA (Rajović, 2016b). The child learns through active participation.

The best practice for walking is walking, the best practice for running is running, the best practice for skiing is skiing. Every time a child performs a new activity, new connections are formed in the brain. Through the repetition of a learned movement, the established brain

connections are strengthened. Therefore, it is necessary to allow children as many different motor activities as possible, such as crawling, climbing, rolling, walking, running, jumping, balancing, and spinning. “Chinese jump rope” is one of the most complex and useful exercises for children. It includes the so-called intuitive movements, which are usually associated with children’s play. Kids learn through play. When a child is immersed in play, many associative connections between neurons are established during the brain’s REM state, when information is edited, consolidated, and stored into the corresponding memory bank. Movements, in the form of games, trigger the release of special substances in the brain - transmitters that give the child a feeling of happiness, comfort, and satisfaction.

Of particular importance in a child’s movement development is exploration in nature. Jean Piaget, the father of developmental psychology, understood and defined childhood as a time when we are particularly motivated to explore nature. The assumption is that a child is emotionally and mentally in equilibrium when they are in nature. Evolutionarily, Homo sapiens have always learned from nature and adapted to natural laws.

Parents often make mistakes because of a lack of knowledge or fear that they will get hurt while playing. Parents are often overprotective of their children. This results in a child not having enough encouragement, not being active enough, thus not gaining new experiences necessary for his or her mental and personal development. We need to let kids play in the mud, sand, trees, or water. Let them get dirty.

Play is an essential factor in human mental development, providing emotional capital and mental “software” (Brussoni, 2019). It is not unique to humans, games and play are also present in animals. Paediatric research has found how important a child’s contact with nature is, as this is where they encounter unsupervised play, risky play, and play with their peers. Many parents and their children live without direct contact with nature. Depression or phobias in adulthood often result from a lack of play in childhood. The child needs to be given a choice of play, including risky play. Enjoying freedom of movement with a certain amount of fear creates a mixture of excitement and curiosity (Marjanovič-Umek & Zupančič, 2001). Risky games such as climbing, jumping, rollerblading, cycling, hiding, and similar activities involve intense attention and concentration, while primarily developing the prefrontal cortex - the frontal lobe of the brain which is home to intellectual processes, associations, coordination, and global motor skills (Brussoni, 2019). In the last few years, there has been a dramatic reduction in children’s opportunities to play freely, without adult supervision or with the possibility of a little risk. Their parents did not grow up being allowed to play risky games, and as a result, they do not let their children play in this way, for fear of them getting hurt. However, risky play has an evolutionary foundation. During human development, man has had to overcome fear, solve dangerous situations, seek solutions in cruel nature, and stay emotionally balanced to survive (Brussoni, 2019).

Thus, parents have the most significant role and responsibility for the development of their child’s abilities. They spend the most time with the child and are most closely attached to it. The more encouragement to move they receive from their parents, the denser the neural networks will become. Inactivity results in fewer connections between neurons and gaps form in the structure of the brain. Separate areas of the brain have specialized functional centres (speech, fine motor skills - graphomotor skills, balance, sensorimotor skills). Depending on which part of the brain these gaps occur, the results can be seen in school as various learning difficulties, dyslexia, speech impairments, reading difficulties, lack of concentration, and motor incompetence.

According to some research, about 50% of children have problems with fine motor skills - graphomotor skills (Rajović, 2016b). While global motor skills are related to the coordination and control of moving different parts of the body, fine motor skills result from the connection and coordination of the palms of the hands, fingers, and eyes. Indications of development in this ability are writing, drawing, and manual dexterity. The period from 2 to 7 years of age is vital for the development of fine motor skills. Graphomotor skills are important for the activation and stimulation of the cerebral cortex and, thus, for the child's general intellectual development (Rajović, 2016b). Sculpting playdough, handling various objects such as balls, sticks, blocks, daily tasks such as feeding, dressing, tying shoelaces, all develop fine motor skills. Graphomotor skills are made up of several different abilities, the most important of which are: visual perception, visual-motor coordination, kinaesthetic feedback, along with voice synthesis and analysis. For a child to start writing, which is one of the most demanding graphomotor activities, they must first undergo complete motor development. This begins with gross - global motor skills (sitting, crawling, walking, and running) and continues with fine motor skills, palm, and finger control. Graphomotor skills are fundamental to the development of synapses in the brain. As such, they are important for the development of a child's potential.

Sophisticated and coordinated hand movements act directly on the sensorimotor development of the nervous system and, through it, on speech development, which represents the highest level of sensorimotor coordination. By stimulating general motor skills, we directly influence the development of speech organs (Malina et al., 2004). Throughout history, hands made up of numerous bones, joints, and ligaments, have created superior works in art, painting, sculpture, architecture, music, engineering, and medicine. The child must first master coordinated and harmonious kinaesthetic control of hand movements. Development begins with moving the hand away from the body and the thumb away from the palm. The child first learns to catch larger objects (a ball) and later smaller ones. Undoubtedly, playing and manipulating various objects (balls of different shapes, sizes, weights, sticks, jump ropes, blocks, and other small props) has extremely positive effects on fine motor skills (Videmšek & Pišot, 2007; Pišot, 2012). Kinaesthetic memory develops through the development of finger motility. The final phase of sensibilization and differentiation of finger motor skills is the mastery of graphomotor skills, i.e., writing and drawing.

Further, neuroscientists studying the development of the nervous system find that the development of children's speech is related to finger motor skills development. When the development of fine motor skills lags behind, the development of speech also lags behind. The influence of impulses from the muscles of the hands affects the formation of motor speech functions. For this reason, diverse activities such as shaping playdough, stacking blocks, or other objects, gluing, cutting, and doing other various crafts are essential. The hands send important information to the central nervous system and are involved in human communication in both verbal and kinaesthetic expression.

Do modern "electronic toys" such as phones, iPads and other electronic tablets also develop fine motor skills? Only partially since we only activate two fingers while using them. However, the effective development of graphomotor skills requires the activity of the entire palm and all our fingers. A rich and stimulating environment is needed for a child's holistic, motor, and intellectual development. Does school, in which children spend more than a third of their active time, fit into this environment? A frequent comment made by children and adolescents is "I don't like school", or even "I hate it." The famous humanist, pedagogue, and philosopher Jan Amos Komensky wrote: "School must be a game." But is it? Children often

experience acute stress in the school environment. They have to learn large amounts of data, repeat it, memorize it, and eventually demonstrate its mastery. It is a reproductive mode of learning that is at odds with the functional operating of the brain. Our brain works on the principles of associations, comparisons, and image memory. Our school system has recently started to take heed of this with so-called interactive lessons. Associative learning provides functional knowledge or functional literacy, which is vital for the effective understanding of texts, the use of acquired information in everyday life, the recognition of essential natural laws, and sensibility of any conclusions.

According to the PISA (Program for International Student Assessment) for 2019, Slovenian students exceeded the average of their peers from other members of the OECD in the subject areas of mathematics, reading literacy, and tasks based on problem-solving. Every year, 540 thousand 15-year-olds from 72 countries are involved in the international PISA project. In recent years our students have shown progress mainly in reading literacy. The best students come from China, Singapore, Japan, Estonia, and Finland (Programme for International Student Assessment (n.d.).

The effective development of a nation's brain potential will decide the future perspective of a nation (Rajović, 2016b). Only associative learning creates new brain connections and, thus, creative and successful individuals.

What does modern life bring? Children spend more and more time in front of TVs, computers, iPads, and other electronic and communication devices. Their world of communication is no longer real; their world is artificial - virtual. This, too, has already shown consequences. In his book, the German researcher Manfred Spitzer (2016) talks about the so-called "digital dementia" of young people, resulting from modern visual and communication technologies. When children look at a screen, they perceive the image as one-dimensional - planar, thus not activating dynamic accommodation - an adaptation of vision. As this means that the child is not developing balance, the eyes are not following the movement of the objects, and the child is not pursuing an object that is approaching or moving away from him or her. As such, the eye is not sending realistic images of the outside world to the visual centre located at the back of the brain. Unmodified vision can also cause problems with reading and writing, and consequently, communication and speech.

Walking, running, jumping, climbing, spinning, bowling, cycling, and other dynamic exercises keep the brain active, as they require balance. Children do not walk, run, and move enough in their natural environment. Walking barefoot was a habit for many past generations that children today hardly know of, even though barefoot walking and running on grass or sand develop a proper arch of the foot most effectively. A five-year-old child can walk four or more miles a day. According to some data, as many as 60% of children today have flat feet or a predisposition for flat feet. Fifty years ago, the percentage of children with flat feet was only 15% (Rajović, 2016b). This is clearly due to the lack of natural movements such as walking and running and exacerbated by inappropriate footwear. Adult hypokinesia and, more recently, of children, undoubtedly has increasingly visible consequences, reflected in the reduced quality of life of modern man.

CONCLUSION

The development of children's mental and motor potential is a dynamic process related to many factors, among which family, pre-school institutions, schools, a stimulating social environment, and, last but not least, genetics, play decisive roles. Technological progress and the development of modern science allow us to understand children's mental and psychophysical development better. Early childhood is one of the most critical periods of a child's development. During the pre-school years, most of a person's brain connections develop, forming the framework for the child's later characteristics and abilities. A stimulating and varied motor environment undoubtedly has a significant impact on children's intellectual function and, thus, on the development of their potential abilities.

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MOTORIČKI I INTELEKTUALNI RAZVOJ DECE: PREGLED

Cilj ovog narativnog preglednog rada je da se predstave efekti fizičke aktivnosti na motorički i kognitivni razvoj dece. Rano detinjstvo je jedan od najkritičnijih perioda detetovog fizičkog i intelektualnog razvoja. Čak sedamdeset posto moždanih veza razvija se tokom predškolskih godina, te veze čine osnovu i okvir za kasnije detetove sposobnosti i karakteristike. Fizički podsticajno i raznovrsno okruženje nesumnjivo ima značajan uticaj na mentalne funkcije dece. Mozak je dizajniran da uči i rešava probleme, u početku jednostavne, a kasnije složene. Najraniji izazovi koje mozak treba da reši povezani su sa kretanjem. Deca ove probleme rešavaju spontano, intuitivno i na nestrukturiran način. Kasnije, organizovanijim pokretima, deca stiču različite motoričke veštine, sposobnosti i čulna iskustva, čime stiču novo razumevanje sebe i svoje okoline. Ovi uvidi i iskustva osposobiće dete za izazove i probleme sa kojima će se suočiti kasnije u životu. Deca kreću u socijalne interakcije i grupnu dinamiku i stiču osećaj samostalnosti i nezavisnosti. Podsticajno i raznovrsno motoričko okruženje nesumnjivo ima značajan uticaj na intelektualnu funkciju dece, a time i na razvoj njihovih potencijalnih sposobnosti.

Ključne reči*: motorički razvoj, kognitivni razvoj, fizička aktivnost, deca*

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Research article

THE VERTICAL JUMP AND SPRINT PERFORMANCE AS DETERMINANTS OF AGILITY AMONG MALE ADOLESCENTS

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Abstract. *The aim of this cross-sectional study was to determine the relationship between the vertical jump (VJ) and sprint performance with agility among male adolescents. The study was conducted on 42 male elementary school students, (age, 13±0.5 years). Among the predictor variables, the Squat Jump (SJ) and Countermovement Jump (CMJ) VJ height were assessed by the Optojump (Microgate, Italy) optical system, and sprint times at 5, 10 and 30 m were assessed using the photocells timing system Witty (Microgate, Italy). Agility as a criterion was assessed with the agility T-test, timed also with photocells. Obtained results showed a significant negative relationship between SJ, CMJ and agility (r=-0.52; -0.58, respectively) and a positive relationship between sprint times at 5, 10 and 30 m and agility (r=0.43; 0.53; 0.57, respectively). A backward stepwise regression analysis showed that the CMJ was the best single predictor of agility (R^2=0.34). The results of this study illustrate that enhancing jump and sprint performance will bring better times in agility performance. Finally, the CMJ has best influence on agility among all the predictor variables.*

Key words: *Relationship, Squat Jump, Countermovement Jump, Sprint, Agility, Adolescents*

INTRODUCTION

Success in variety of sports is dependent on numerous motor skills, but in multidirectional sports where players are engaged in rapid changes of direction and short bouts, power, speed and agility are crucial abilities that can affect performance and advantages in game situations (Bompa & Haff, 2009; Delextrat & Cohen, 2009; Garcia-Gil et al., 2018). It has been suggested that agility is one of the determinant factors in upcoming success and optimal performance in younger athletes (Mirkov, Kukolj, Ugarković, Koprivica, & Jarić, 2010; Lloyd et al., 2013). Development spurt in agility performance occurs in adolescence at

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approximately the age of 13-14 in male adolescents, which is proportional with the occurrence of peak height velocity (PHV) (Vänttinen, Blomqvist, Nyman, & Häkkinen, 2011; Lloyd et al., 2013). Therefore, assessment of physical fitness and the identification of performance predictors are important for the selection and screening of young athletes (Norkowski, 2002; Gonçalves, Rama, & Figueiredo, 2012; Ferreira et al., 2019).

Agility is often defined as a complex set of interdependent abilities needed to change whole-body movement direction, velocity or mode as an answer to stimulus (Sheppard & Young, 2006; Bompa & Haff, 2009; Nimphius, Callaghan, Bezodis, & Lockie, 2018). According to some research, underlying factors of this definition appear to be muscle strength and power with the potential of stretch-shortening cycles (SSCs) as a capacity to perform short sprints and fast changes of direction with a great efficacy (Gabbett, Kelly, & Shepard, 2008; Castillo-Rodríguez, Fernández-García, Chinchilla-Minguet, & Carnero, 2012; Spasić, Uljević, Coh, Dželalija, & Sekulić, 2013). One of the effective training method is plyometric training in order to "learn" and "gain" SSC capabilities in younger athletes (Stojanović & Kostić, 2002; Stojanović, Jovanović, & Stojanović, 2012).

A number of previous studies that have investigated the relationship between jump performance and agility reported significant negative correlations between the Squat Jump (SJ), Countermovement Jump (CMJ) and agility most commonly assessed with the T-test (Pauole, Madole, Garhammer, Lacourse, & Rozenek, 2000; Alemdaroğlu, 2012; Castillo-Rodríguez et al., 2012; Asadi, 2016; Negra et al., 2017). Furthermore, studies that have investigated the relationship between sprint performance and agility also reported significant positive correlations between the T-test and 10 and 20 m sprints (Negra et al., 2017), 30-m sprint (Alemdaroğlu, 2012), also 20 and 40-yard sprints (Peterson, Alvar, & Rhea, 2006). Chaouachi and associates (2009) revealed no significant correlations between 5, 10, and 30 m sprint times and the agility T-test.

From the mentioned previous studies it is evident that the most often used test in the agility assessment was the T-test. It is a standard test of agility with good reliability and validity characteristics (Pauole et al., 2000). It is simple to use (minimal equipment and preparation). The T-test includes speed and four changes in direction. The most accepted field tests used in lower limb power and performance evaluation are the vertical jump (VJ), SJ and CMJ (Stojanović, Čoh, & Bratić, 2016; Petrigna et al., 2019; Aksović, Kocić, Berić, & Bubanj, 2020). Scientific literature on how to train agility for children and adolescents in the best possible manner is limited (Lloyd et al., 2013). Optimization of the agility training programs, a correlation analysis with other physical fitness parameters (muscle strength and power, speed, etc.) is needed (Negra et al., 2017).

The aim of this study is to determine the relationship between VJ and speed performance with agility among male adolescents.

METHODS

The sample of participants

A total of 42 seventh grade elementary school male students (age: 13±0.5 years; body height 165.78±8.98 cm; body mass: 56.43±10.63 kg; body mass index: 20.43±2.72 $kg \cdot m^{-2}$) participated in this cross-sectional study. The study sample involved only students who voluntarily agreed to participate in the study followed by the testing program. Prior to the study, parental consent was obtained for every participant. This study was conducted in

compliance with the recommendations for clinical research of the World Medical Association Declaration of Helsinki (2013) and the children's privacy was protected by allowing for anonymity. This study was also reviewed and approved by the Ethics Committee of the Faculty of Sport and Physical Education, University of Niš. All of the participants were clinically healthy during the testing protocol.

Procedures

The testing procedures were carried out in two days. On the first day, anthropometric measurements were taken early in the morning and performance measurements (VJs and sprints) were performed in the afternoon. The agility test was performed on the second day in the afternoon.

Anthropometric measurements. Body height was measured using a Martin anthropometer GPM 101 *(GPM GmbH Switzerland)* to the nearest 0.1 cm. Body mass was measured with an accuracy of 0.1 kg using the Omron BF511 digital scale *(Omron Healthcare Co, Kyoto, Japan).*

Vertical jump. VJ performance was assessed based on the SJ and CMJ using the Optojump (*Microgate, Italy*). The Optojump system is a dual-beam optical device which detects any interruptions in communication between beams and makes it possible to measure flight and contact times during jumps with an accuracy of 0.001 s. VJs were performed following the Bosco protocol (Bosco, Luhtanen, & Komi, 1983). The participants performed a standardized warm-up before testing procedure. Jump height was recorded to the nearest 0.1 cm.

Sprint. Sprint performance was assessed by a linear 30-m sprint test with split times at 5 and 10 m. The participants performed two all-out effort 30 m sprints on an indoor wooden (parquet) court. Before the testing procedure, participants performed a standardized warm-up. The recovery period was approximately 2-3 minutes between the sprints. Sprint and split times were measured with four Witty photocell gates (*Microgate, Italy*), positioned at the starting line, 5 m, 10 m, and finish line, with an accuracy of 0.01 s (Fig. 1).

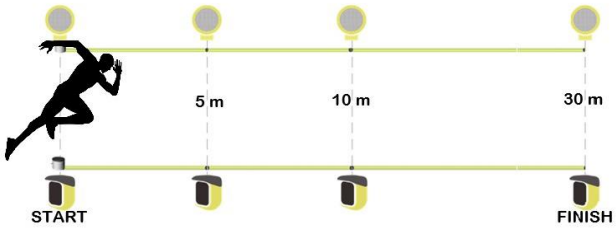

Fig. 1 Graphical layout of linear 30-m sprint test with split times at 5 and 10 m

Agility. Agility was assessed through the T-test following the protocol outlined by Semenick (1990). Time was measured with one Witty photocell gate (*Microgate, Italy*) mounted on a tripod with a height of 0.75 m at the starting line, with an accuracy of 0.01 sec (Fig. 2). The reliability and validity of the T-test were confirmed by Pauole et al. (2000).

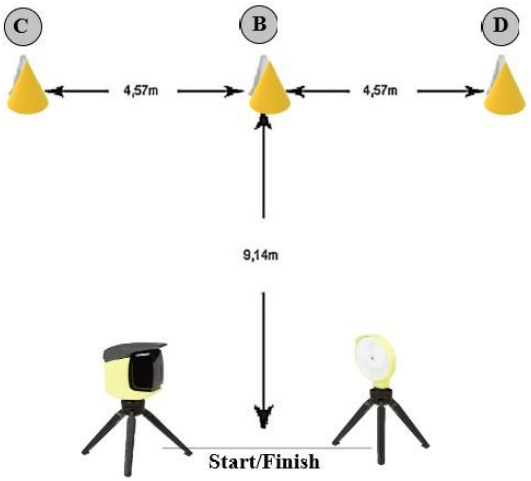

Fig. 2 Graphical layout of the agility T-test

Statistical analyses

The arithmetic mean (Mean) and standard deviation (SD) values were calculated for each variable. The Kolmogorov-Smirnov test was applied to confirm normality. The relationships between VJ performance, sprint performance and agility were evaluated using Pearson Product Moment Correlation analysis. Cohen (1988) recommended that 0.10 to 0.30 should be interpreted as a weak correlation, 0.30 to 0.50 as a moderate correlation and greater than 0.50 as a strong correlation. A multiple regression analysis with backward stepwise method was used to estimate the best predictor model of agility. Coefficients of determination (R^2) were used to interpret the proportion of the variance of the T-test that is predictable from the independent variables. Statistical significance was set at level $p<0.05$.

Statistical procedures and analyses were conducted using the statistical package STATISTICA 10.0 for Windows (StatSoft, Inc., Tulsa).

RESULTS

The results for the VJ, sprint and agility tests are reported in Table 1.

Table 1 Descriptive data for all the variables

(n = 42)	Variable	Mean	SD	Min	Max
Vertical Jumps	SJ (cm)	22.77	4.73	8.90	30.50
	CMJ (cm)	24.03	4.61	11.30	32.80
Sprint	5-m sprint (s)	1.30	0.13	1.06	1.59
	10-m sprint (s)	2.17	0.18	1.86	2.53
	30-m sprint (s)	5.53	0.43	4.69	6.51
Agility	T-test (s)	13.32	1.63	10.49	16.42

Legend: SJ-Squat jump; CMJ-Countermovement jump; SD-Standard deviation.

The relationship between the performance variables and agility is detailed in a correlation matrix showing the Pearson correlation coefficients (*r*) in Table 2.

Table 2 Pearson's (*r*) correlation matrix of all variables

Variable (n = 42)	SJ (cm)	CMJ (cm)	5-m sprint (s)	10-m sprint (s)	30-m sprint (s)	T-test (s)
SJ (cm)	1.00	0.87*	-0.36*	-0.51*	-0.70*	-0.52*
CMJ (cm)		1.00	-0.29	-0.44*	-0.67*	-0.58*
5-m sprint (s)			1.00	0.92*	0.65*	0.43*
10-m sprint (s)				1.00	0.78*	0.53*
30-m sprint (s)					1.00	0.57*
T-test (s)						1.00

Legend: SJ-Squat jump; CMJ-Countermovement jump; *-significant at level p<0.05.

The agility T-test performance was significantly related to all independent variables (Table 2). Negative strong correlations were found in CMJ and SJ (r=-0.58 and -0.52, respectively) and a strong positive correlation among sprint times at 30 and 10 m (r=0.57 and 0.53, respectively). A moderate correlation was found in 5-m sprint time (r=0.43).

A multiple regression analysis with a backward stepwise method showed that CMJ was the best single predictor (p=0.000) of agility (Fig. 2).

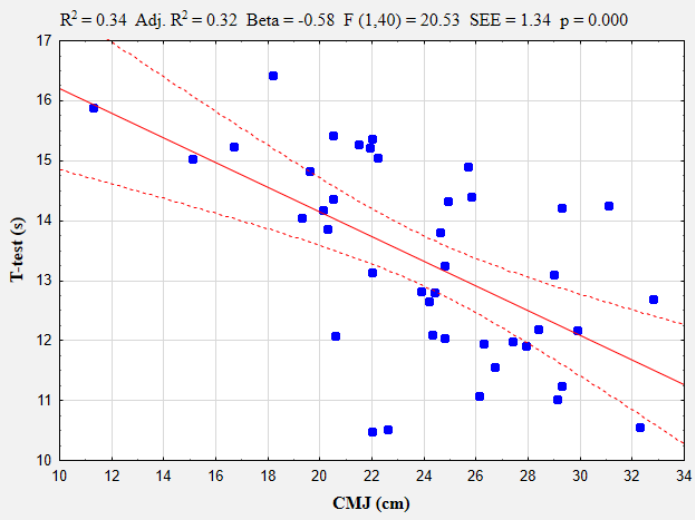

Fig. 3 Linear regression of CMJ as predictor vs. T-test as criteria.

DISCUSSION

The aim of this study was to determine the relationship between VJ and sprint performance with agility in male adolescents.

The main findings of this study indicate that the agility has a strong correlation with jumping performance and a moderate to strong correlation with straight sprint performance.

Also, a stepwise regression analysis showed that the CMJ was the single significant predictor of the T-test performance in male adolescents.

Agility is a very complex multifactorial motor ability which is affected by interactions of strength, speed, balance, flexibility, and muscular coordination (Sheppard & Young, 2006), but it is not yet clear in what proportion they are associated among adolescents. Results from this study clearly demonstrates the presence of a strong negative relationship between jumping performance and agility, indicating that the greater the lower limbs explosive power, the better the time on the agility T-test. In accordance with the obtained results, Negra et al. (2017) reported the same negative relationship between SJ, CMJ and the agility T-test (r=-0.53; -0.58, respectively) among adolescent athletes of a similar age to the participants of this study. Alemdaroğlu (2012) also reported a very similar significant negative correlation between the CMJ and T-test (r=-0.59), but in professional male basketball players. Also, strong correlations were found between jumping performance and the agility test among young basketball players (Asadi, 2016) and students of the Faculty of Physical Education (Castillo-Rodríguez et al., 2012). Pauole et al. (2000) found a moderate significant correlation between the VJ and agility T-test (r=-0.49) in college-aged men. However, our results are in contrast with the findings of Peterson, Alvar, & Rhea (2006) who revealed a trivial to small relationship between the VJ and the agility T-test in young male athletes, and Chaouachi et al. (2009) found no significant correlation between the SJ, CMJ and T-test in elite male basketball players.

Furthermore, the results obtained from the correlation matrix showed that sprint performance demonstrates moderate (5-m sprint time) to strong (10 and 30-m sprint times) positive correlations with agility. According to Vescovi and McGuigan (2008), the relationship between speed and agility increases with longer distances and when examining agility with flying sprint times. In accordance with the results of this study, a similar positive relationship was found between the 30-m sprint and T-test (r=0.50) in elite male basketball players (Alemdaroğlu, 2012), also the 10 and 20 m sprint and T-test among adolescents (Negra et al., 2017). Peterson and associates (2006) revealed a significant correlation between acceleration (20-yard sprint) and speed (40-yard sprint) with the T-test among young athletes. In contrast, Chaouachi and associates (2009) did not find significant correlations between 5, 10, and 30 m sprint times and the agility T-test and in elite male basketball players.

The obtained relationship between jumping and sprint performance with agility can be explained by the major role of muscle contraction factors involved during acceleration, deceleration and rapid change of directions. Elastic properties of the muscles and their stored energy utilized from SSC are necessary for maximal jumping, sprint and agility performance (Komi & Gollhofer, 1997; Young, Miller, & Talpey, 2015). Also, Hermassi Fadhloun, Chelly, and Bensbaa (2011) outlined that the explosive leg power in the CMJ or SJ is a significant aspect of total time of the agility T-test.

Finally, with a multiple regression analysis using the backward stepwise method all variables were excluded from the regression model except CMJ as the single best predictor for agility performance. CMJ explains 34% of agility variance, same as Negra et al. (2017) reported (CMJ: R^2=0.34). Other studies showed that jumping performance explains the agility from ~25% (Jones, Bampouras, & Marrin, 2009; Meylan et al., 2009) up to 46% (Castillo-Rodríguez et al., 2012) of common variance. Spasić et al. (2013) outlined that agility variance explained by power measures infrequently exceeds 50%. A recent study has also proposed a different approach of agility test measurement by removing the confounding

factor of large amounts of linear sprinting (Nimphius et al., 2018). For example, the time taken to run a 10-yard (9.14 m) linear sprint would be subtracted from the time to complete a T-test to calculate the change of direction (COD) deficit which can be a more precise measure of actual agility. The underlying logic behind the COD deficit is that some participants were relying on their better than average acceleration ability (10-m time) to mask their agility performance when assessed using total time (Nimphius et al., 2018). Further studies should investigate the COD deficit in order to gather more precise information about the influence of confounding factors to agility.

CONCLUSION

From the obtained results from this research, it can be concluded that a significant relationship between jumping and sprint performance with agility exists. Furthermore, lower limb explosive power assessed through the CMJ is best single predictor of agility in male adolescents. The results of this study illustrate the significance of developing lower-body muscular strength and power to enhance jump and sprint performance that will eventually affect overall agility performance in male adolescents.

These findings have practical interest for physical education teachers and coaches which suggests that using a field test such as the T-test for agility and CMJ for jump performance assessment, which is easy to administer, consequently maybe used for physical fitness level assessment, also for training modeling and talent identification among youth non-athletes and athletes. One of the limitations of this study is that the CMJ cannot be used as an accurate predictor of agility because a great portion of variance has been left unexplained.

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VERTIKALNI SKOK I SPRINT KAO DETERMINANTE AGILNOSTI ADOLESCENATA MUŠKOG POLA

Sa ciljem da se utvrdi povezanost vertikalnih skokova, sprinta i agilnosti dečaka adolescenata, sprovedeno je istraživanje na uzorku od 42 ispitanika muškog pola, učenika sedmog razreda, prosečne starosti 13±0.5 godina. Prediktorske varijable su činile visina vertikalnih skokova koja je procenjena pomoću testova skok iz čučnja (SJ) i skok sa počučnjem (CMJ), primenom Optojump sistema, zatim brzina sprinta na 30 m sa prolaznim vremenom na 5 i 10 m primenom fotoćelija. Agilnost kao kriterijumska varijabla je procenjena pomoću Agility T-test. Dobijeni rezultati ukazuju da postoje značajne negativne korelacije između vertikalnih skokova SJ, CMJ i agilnosti (r=-0.52; r=-0.58, tim redosledom), kao i značajne pozitivne korelacije između brzine sprinta na 5, 10 i 30 m i agilnosti (r=0.43; 0.53; 0.57, tim redosledom). Stepwise regresiona analiza je pokazala da je varijabla CMJ jedini značajni prediktor agilnosti (R^2=0.34). Zaključuje se da su vertikalni skokovi i sprint značajno povezani sa agilnošću kao veoma kompleksne motoričke sposobnosti, takođe vertikalni skok CMJ ima najveći uticaj razvoj brzine izvođenja testova agilnosti.

Ključne reči: *povezanost, skok iz čučnja, skok sa počučnjem, sprint, agilnost, adolescenti*.

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Research article

RELIABILITY AND VALIDITY OF CHANGE-OF-DIRECTION SPEED TESTS FOR JUNIOR BASKETBALL PLAYERS

UDC 796. 012:323.2

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Abstract. *The main goal of this study was to determine the reliability and validity of change-of-direction speed (CODS) tests for junior basketball players and to test the differences between the positions of players on the team. On a sample of 66 junior basketball players (18.2±3.18 years), the CODS was tested using the following tests: the Lane Agility Test (LAT), Zigzag Agility Test (ZAT), Agility T-test and Modified Agility T-test. Body height and body mass were used as control variables. α-Cronbach's coefficient was calculated to determine the reliability and internal consistency of the measurements, as well as the average correlation between the trials of each test. The difference between groups of players was tested by MANCOVA. CODS tests showed good to high reliability (interclass correlations ranged from 0.83-0.93 with a variability of 4.4% to 6.4% for the entire sample). The first principal component was determined, which included 83% of the total variance of the analyzed variables. Very high coefficients of internal validity of all the applied tests (0.93-0.98) were obtained on the common subject of defined measurements. Significant differences were found between groups of players by position in favor of outside players (guards) on two tests LAT and ZAT (F=18.023; 8.559 and p≤0.005) with control of the influence of body height and body mass. All tests can be rated as reliable and valid for junior basketball players. LAT proved to be the most suitable for assessing the CODS in young basketball players, with the best discrimination of players by position on the team.*

Key words: *Change-of-Direction Speed, Young Basketball Players, Reliability, Validity, Positional Differences*

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INTRODUCTION

Basketball is a team sport in which each player coordinates his individual technique and individual tactics with his teammates through the team's collective tactics (Perica, Trninić, & Jelaska, 2011). Most of the key elements of basketball take place in anaerobic mode with high-intensity activities such as short sprints, rapid changes of direction, jumps, and other movements that come from the Creatine phosphate system (Delextrat & Coen, 2009). As many as 20.7% of sprint activities in basketball represent changes in the direction of movement, which indicates the importance of the change-of-direction movement speed among basketball players (Conte et al., 2015; Stojanović et al., 2019). The ability to quickly change direction, while maintaining balance, using a combination of strength, force, and neuromuscular coordination was once defined as agility (Baechle & Earle, 1994). However, agility is now defined as the ability of a body to move rapidly with a change in direction or speed of movement that occurs in response to an external stimulus (Sheppard & Young, 2005). This further indicates that agility must be separated into components of perception and speed of decision making on the one hand and change-of-direction speed on the other (Barnes et al., 2007), i.e., these components must be evaluated separately. The change-of-direction speed (CODS) is mostly under the influence of factors such as the quality of leg muscles, i.e., reactive and explosive power (Young, James, & Montgomery, 2002; Marković, Dizdar, Jukić, & Cardinale, 2004; Alemdaroğlu, 2012), individual strength of the legs (Young, Wilson, & Byrne, 1999) and linear velocity (Sheppard & Young, 2005; Vesković & McGuigan, 2008). It was also found that other abilities such as balance and technique of performing motor activities are significantly correlated with the change-of-direction speed (Sayers, 2000; Young & Farrow, 2006).

The ability to quickly change the direction of movement as a component of agility plays an important role in the structure of the basketball game. The importance of determining the level of CODS is primarily significant in recognizing talent (Pearson, Naughton, & Torode, 2006). The various field test protocols used to estimate the change-of-direction speed (CODS) must be valid and reliable for practical use. In sports practice, specific tests such as Lane Agility Drill, Reactive Shuttle Test-used in NBA when drafting players are most often used, while the most widely used tests with young players are the standardized Agility T-test (Delextrat & Coen, 2009; Sekulić, Uljević, Perić, Spasić, & Kondrić, 2017), Zigzag Drill Test (Bloomfield, Ackland, & Elliot, 1994; Karalejić & Jakovljević, 2009) and Y-shaped Agility Test (Lockie, Jeffriess, McGann, Callaghan, & Schultz, 2014). Although most of these tests contain some of the movement patterns used in basketball (running forward, running backwards and side step movement), different results obtained in the application of these tests in basketball players indicate certain shortcomings in diagnostics of the change of direction movement speed (Paoule, Madole, Garhammer, Lacourse, & Rozenek, 2000; Delextrat & Cohen, 2008; Chaouachi et al., 2009; Brown, 2012). In general, the limitation of these tests is primarily reflected in the small number of changes of direction-direction of movement, the distance covered between changes of direction of movement, the total distance traveled and the deficiencies of patterns of movement which occur during a basketball game. It is very important to emphasize that when applying tests to evaluate the CODS one should take into account the position of the player on the team, the level of competition as well as the age category.

Previous research has shown different results in the application of the Agility T-test (Abdelkrim, Chaouachi, Chamari, Chtara, & Castagna, 2010; Jakovljević, Karalejić, Pajić,

Gardašević, & Mandić, 2011; Köklü, Alemdaroğlu, Koçak, Erol, & Fındıkoğlu, 2011; Sekulić et al., 2017).

Therefore, the main goal of the current study was to determine the reliability and validity of CODS tests for junior basketball players and to test the differences between positions of players on the team.

METHOD

Participants

The study included a sample of 66 junior basketball players (18.2±3.18 years) who had to meet certain requirements: at least 10 games played during the season, attendance on at least 75% of training sessions during the season, minimum playing experience of 7 years and no serious sports injuries for at least two months before testing. The probabilistic sample included six first-ranked teams of the HEBA single junior league in the 2012/2013 season (B.C. Partizan, B.C. Crvena Zvezda, B.C. Vršac, B.C. Žitko Basket, B.C. Borac, B.C. Sloboda). The teams had approximately the same number of training sessions in the micro cycle (6-8). The entire sample is divided into two sub-samples according to player positions: outside players (point guards and shooting guards and small forwards, N=39) and inside players (power forwards and centers, N=27). Background data was collected based on a survey completed by the players two days prior to testing.

Measuring Instruments

Four tests were used to assess the change-of-direction speed: the Lane Agility Test (LAT), Zigzag Agility Test (ZAT), Agility T-test (TT) and Modified Agility T-test (MAT) (National Basketball Conditioning Coaches Association, 2000; Bloomfield et al., 1994; Pauole et al., 2000; Sassi et al., 2009). A system of photocells with a PLC (Unitronics, ACE-Automatic Control Engineering, USA) was used for measurement. Anthropometric measurements included measurements of body height (Seca SE206, UK) and body mass (Tanita BC-540, GER).

Procedures

The testing was realized in the sports halls where the teams train every day. The players were randomly divided into two groups. Body height and body mass were first measured, after which the examiners performed standard warm-ups consisting of light to moderate running for 5 to 10 minutes, static and dynamic stretching exercises for 5 minutes, short-distance accelerations with changes of direction, and innervation exercises using agility ladders. After that, testing of motor tasks was performed. The choice of the order of tests was random. Players had three trials for each test with a minimum passive break of 2 minutes between attempts and a break of 5 minutes between each test. All achieved measurement results were recorded in a specially prepared measurement sheet in units (1/100 second). The players started the test from a standing position with their feet placed 20 cm behind the starting line.

Lane Agility Drill (Figure 1). The player stands in a standing position behind the starting line, facing the base line of the basketball court. On the examiner's mark, the player sprints forward towards the baseline to cone B (5.8 m). Then he slides sideways to cone C (B to C

4.9 m) where he starts running backwards to cone D (5.8 m) and then slides sideways to cone A (4.9 m). When the player steps on the line that is an extension of the side line of the paint, he returns in the opposite direction, by sliding sideways. Recording time stops when the player reaches the starting position again.

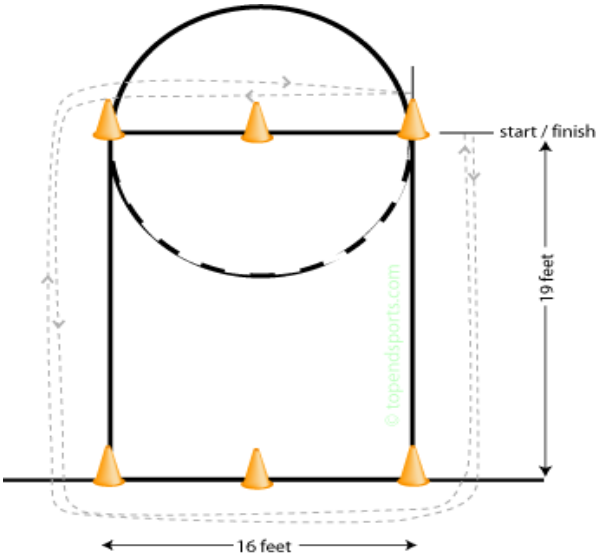

Fig. 1 Lane Agility Test

Zigzag Agility Test (Figure 2). The player assumes a standing position behind the starting line of cone 1. On the examiner's mark, the player sprints diagonally towards the free throw line to cone 2. Then sprints to right to cone 3 and to cone 4 and at the end of the sprint to cone 1, i.e., the starting position. The time stops when the player crosses the starting line-level of cone 1.

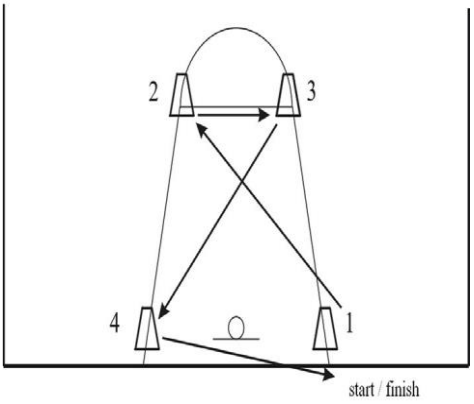

Fig. 2 Zigzag Agility Test

Agility T-Test (Figure 3). The player assumes a standing position behind the starting line. On the examiner's mark, the player sprints to cone B, touches it with his right hand. After he slides sideways towards cone C and touches it with his left hand. After he slides sideways to cone D and touches it with his right hand. He slides sideways again towards cone B, touches it with his left hand and runs backwards towards cone A. Recording time stops when the player crosses the line of cone A.

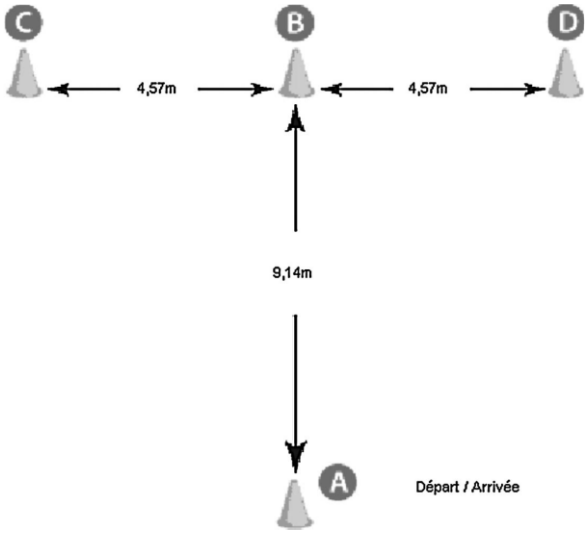

Fig. 3 Agility T-Test

Modified Agility T-test (Figure 4). The test is performed in the same way as the Agility T-test with the only difference in the total distance crossed in the test.

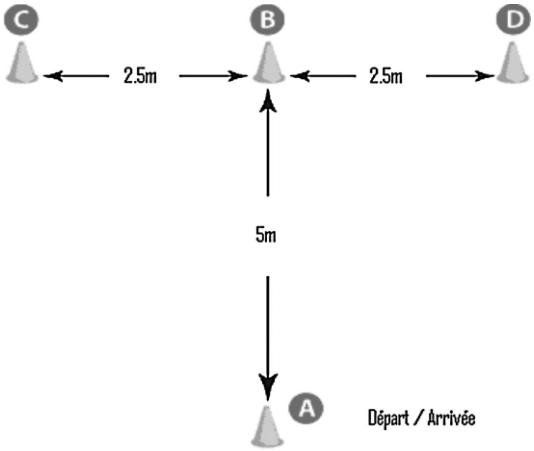

Fig. 4 Modified Agility T-Test

Statistical Data Analyses

The following basic central and dispersion parameters of the results were calculated for all variables and measurement particles: arithmetic mean (M), standard deviation (SD), skewness (Skew) and kurtosis (Kurt). The coefficient of variability for the average values of the variables was also calculated separately for each group (CV). Using the Kolmogorov-Smirnov test, the normality of the distribution of results was tested. The average result from the three measurement sessions was determined for all participants in the analyzed variables, and was used in the further analysis of the internal validity of the tests.

To determine the reliability and internal consistency of the measurements, α-Cronbach's coefficient was calculated, as well as the average interclass correlation between the trials of each test (ICC), as a measure of the homogeneity of the composite motor test. The first principal component was determined from the test measurement trials by the principal component method (H). Correlations of the measurement trials with the principal component were used to assess the internal validity of the measurement trials in the analyzed tests. The internal validity of the tests was determined by the principal component method (PCA) based on the correlations of the tests with the principal component. The difference between groups of players in test results was tested by the Multivariate Analysis of Covariance (MANCOVA), with control of body height and body mass. Data analysis was performed using IBM SPSS software package, version 20.

RESULTS

The results of the Kolmogorov-Smirnov test show that the distribution of the results in all variables does not deviate statistically significantly from the normal distribution (Table 1).

Table 1 Data distribution characteristics for the entire sample

Variables	Skew	Kurt	KS (z)	KS (p)
Body height	0.28	-0.41	0.75	0.62
Body mass	0.59	0.57	0.95	0.33
Lane agility Test	0.16	-0.36	0.49	0.97
Zigzag agility Test	0.42	0.93	0.84	0.49
Agility T-test	0.44	-0.55	0.92	0.37
Modified T-test	0.70	0.42	1.01	0.26

Legend: Skew-skewness; Kurt-Kurtosis; KS-Kolmogorov-Smirnov Test: z-Value, p-Significance.

The asymmetry of the distribution was not disturbed in any of the analyzed variables (Skew). The homogeneity of the distribution of the results (Kurt) indicates greater homogeneity of the participants or reduced discrimination in the ZAT and MAT tests (0.418; 0.931) while in the LAT and TT tests a reduced homogeneity of the results was observed (-0.355; -0.555).

Significant homogeneity of the results was observed in all measurement trials of the analyzed tests, which indicates high homogeneity of the sample of participants (Table 2).

Table 2 Descriptive statistics and indicators of reliability and validity of analyzed tests

Variable	Trials	Outside players			Inside players					
		M	SD	CV	M	SD	CV	H	α	ICC
Body height (cm)		189.30	6.34		198.38	7.84				
Body mass (kg)		79.52	7.06		93.26	9.49				
Lane Agility Test (s)	1	12.07	0.83		13.18	0.87		0.98		
	2	11.80	0.73		12.79	0.82		0.98	0.97	0.93
	3	11.72	0.76		12.64	0.75		0.97		
	Average	11.87	0.76	6.40	12.87	0.78	6.10			
Zigzag Agility Test (s)	1	5.92	0.32		6.22	0.31		0.95		
	2	5.83	0.27		6.17	0.28		0.96	0.95	0.87
	3	5.80	0.24		6.16	0.35		0.95		
	Average	5.85	0.26	4.40	6.19	0.30	4.80			
Agility T-test (s)	1	9.22	0.46		9.71	0.50		0.95		
	2	9.08	0.50		9.59	0.52		0.98	0.96	0.90
	3	9.08	0.61		9.58	0.54		0.96		
	Average	9.13	0.50	5.50	9.63	0.50	5.20			
Modified T-test (s)	1	5.60	0.39		5.89	0.40		0.93		
	2	5.44	0.28		5.77	0.40		0.96	0.93	0.83
	3	5.44	0.32		5.75	0.36		0.93		
	Average	5.50	0.31	5.60	5.80	0.37	6.40			

Legend: M=arithmetic mean; SD=Standard Deviation; CV=Coefficient of Variability; H=Correlations of the Measurement Trials with the Main Component; α=Cronbach's Alpha Coefficient; ICC=Interclass Correlation Coefficients.

Cronbach's reliability coefficients (α) show that all four applied tests have high reliability with coefficients in the range of 0.93-0.97. Correlations of particles with the first principal component are high and indicate good internal validity of measurements (H=0.96-0.98). The second measurement trial has the highest correlation with the first subject of measurement in all tests. The ICC are high and show that all measurement trials have the same subject of measurement, i.e., high homogeneity (0.83-0.93).

The correlations of the analyzed variables were high and statistically significant, and the PCA isolated one characteristic root that describes 83% of the total variance of the analyzed variable. The correlations of the analyzed variables with the first main component varied between 0.87 and 0.93 and indicates a well-defined common subject of measurement in the applied tests. The TT and LAT showed the greatest validity (0.94 and 0.93 respectively). Only the MAT had a lower correlation with the first main component.

The examination of the total differences between outside and inside players with control of body height and mass showed the presence of a statistically significant difference ($F=5.75$; $p=0.001$) with a high effect of the difference ($Eta^2=0.28$) (Table 3).

Table 3 Results of the analysis of covariance

Variables	M1	M2	F	p	Eta^2
LAT (s)	11.8	12.87	18.02**	0.001	0.23
ZAT (s)	5.85	6.19	8.56**	0.005	0.12
TT (s)	9.13	9.63	5.14	0.027	0.08
MAT (s)	5.49	5.80	6.66	0.012	0.10

Legend: F-Ratio; p-Level of Significance; Partial Eta^2-Effect Size.

Thereby, a significant influence of body mass on the results of all tests was observed (p=0.022; 17.4% variance). An individual influence of the position in the team, with a Bonferroni corrected alpha level of 0.0125, was obtained in the tests LAT and ZAT with an explanation of 22.5% and 12% of the variance difference, respectively.

DISCUSSION

This study explored the reliability and factor validity of four tests of CODS that are often used in practice with elite young basketball players. All analyzed tests showed high reliability of measurement results. Previously obtained high Cronbach's (α) coefficients, ICC and moderate variability of the results (CV) on a sample of students, football players and students of sports studies in relation with TT and MAT confirm the reliability of measurement results obtained in this study (Stewart, Turner, & Miller, 2012; Sassi et al., 2009; Sekulić, Spasić, Mirkov, Čavar, & Sattler, 2013; Sporiš, Jukić, Milanović, & Vučetić, 2010). Furthermore, other research results (Chaouachi et al., 2009; Brown, 2012; Stojanović et al., 2019) show a very high reliability of test measurement results used for the assessment of CODS in basketball players.

A more detailed comparison of our and results from previous research is difficult given the application of different protocols (tests) and the generally insufficient number of studies that examined changes in the direction of movement in a sample of basketball players. The CV of the results obtained in this study deviates minimally from the results obtained in Brown's study (2012), while slightly lower values of CV were obtained in some other studies (Pauole et al., 2000; Chaouachi et al., 2009; Sassi et al., 2009; Stewart et al., 2012). This can be elucidated by the differences in the sample by age and entities that were not basketball players in the given research. Slightly higher CV values in the LAT and MAT test compared to the TT and ZAT can be explained by greater complexity of the task in LAT because it contains changes of direction, lateral movements in posture and running backwards, while the CV in the MAT test can be explained by the shorter duration of the test as well as changes in the direction of movement on a smaller area.

High correlations of the measurement trials with the first principal component were found, which indicated a good internal validity of the trials. In all the test measurement trials, a result stabilization tendency was observed in the second performance, which was obtained on a similar sample in the study of Stojanović and associates (2019). On the other hand, the low variability in the ZAT test can be explained by the "simplicity" of the motor task, while in the TT test it can be explained by previous knowledge or acquaintance with this test (4.4-4.8% and 5.2-5.5%), which was confirmed by studies (Chaouachi et al., 2009; Brown, 2012) on a sample of basketball players.

The obtained moderate to high positive correlations between all applied tests (0.671-0.867) coincide with the results of previous research in tests that are commonly used to assess the CODS in basketball players (Brown, 2012; Stojanović et al., 2019) but also in a sample of university athletes (Pauole et al., 2000; Sassi et al., 2009; Sekulić et al., 2013). A slightly weaker correlation of the MAT test with the LAT and ZAT tests could indicate slightly lower metabolic requirements (5.50 s) as well as the number of changes of direction of movement.

The first principal component of the sample of applied tests covered 83% of the total variance. The correlation of the tests with the first principal component showed that all of

the tests used are good for assessing the CODS in young basketball players. In addition to being used in discovering talents, the applied tests can also be used in training to improve this component of agility.

Furthermore, when assessing the CODS, the positions of the players in the team and their body constitution must be taken into account. This is indicated by statistically significant differences between positions of the players in the team obtained in this research. The obtained results suggest that the LAT and the ZAT provide good discrimination of players according to their positions in the team, with the control of effects of body height and mass. Similar differences were obtained in studies dealing with this topic (Bloomfield et al., 1994; Chaouachi et al., 2009; Sporiš et al., 2010; Jakovljević et al., 2011; Erčulj, Brančić, & Jakovljević, 2011; Brown, 2012; Mitić et al., 2019), but without control of effects of body mass and height on test results. A logical explanation for the obtained differences can be found in the data on the intensity of basketball players' activity during the game where outside players (point guards and shooting guards and small forwards) carry out and realize a much larger number of changes of direction of movement and high intensity movements than inside players (forwards and centres) (McInnes, Carlson, Jones, & McKenna, 1995; Abdelkrim, Fazaa, Ati, & Tabka, 2007). The very structure of the tests influenced the differences between the groups of players and is reflected in the complexity of the task, which includes the number of changes in direction, manner of movement and the total distance covered in the test.

CONCLUSION

The results of the current study confirmed the reliability and validity of all applied tests of the CODS specific to basketball. Only the LAT test showed a learning effect, while the other three tests did not. Significant strong correlations between all change-of-direction speed tests in this study showed that each test measured the same ability of junior basketball players. The LAT test was the most sensitive in identifying differences between positions of the players in the team where it explained 22% of the total variance with the elimination of differences in the two anthropometric variables (body height and body mass). Also, the application of these tests in practice is very simple and does not require major monetary investment. In the end, although all analyzed tests in this study showed excellent reliability and validity for junior basketball players, future research should examine and consider their limitations in terms of the construction of the test on a sample which differs by gender, level of competition and experience to obtain long-term validity.

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POUZDANOST I VALJANOST TESTOVA BRZINE PROMENE PRAVCA KRETANJA KOŠARKAŠA JUNIORA

Glavni cilj ove studije bio je da se utvrdi pouzdanost i valjanost testova brzine promene pravca kretanja (CODS) košarkaša juniora i ispitivanje razlika između pozicija igrača u timu. Na uzorku od 66 mlađih košarkaša (18.2±3.18 godina), brzina promene pravca kretanja testirana je pomoću sledećih testova: Lane Agility Test (LAT), Zigzag Agility Test (ZAT), Agility T-test i Modified Agility T-test. Kao kontrolne varijable korišćene su telesna visina i telesna masa. Igrači su imali 3 pokušaja da sprovedu svaki od testova. Koeficijent α-Cronbach je izračunat da bi se utvrdila pouzdanost i unutrašnja konzistentnost merenja, kao i prosečna korelacija između ispitivanja svakog od testova. Razlika između grupa igrača u rezultatima testa ispitivana je analizom MANOVA. Obrada podataka sprovedena je pomoću softverskog paketa IBM SPSS, verzija 20. Svi CODS testovi pokazali su dobru do visoku pouzdanost (međuklasne korelacije kretale su se od 0.83-0.93 sa varijabilnošću od 4.4% do 6.4% za ceo uzorak). Metodom glavne komponente utvrđena je prva glavna komponenta koja je obuhvatala 83% ukupne varijanse analiziranih varijabli. Na zajedničkom predmetu definisanih merenja dobijeni su vrlo visoki koeficijenti interne validnosti svih primenjenih testova (0.93-0.98). U dva testa LAT i ZAT (F=18.023; 8.559 i p≤0,005), kontrolom uticaja telesne visine i telesne mase, utvrđene su statistički značajne razlike između grupa igrača po pozicijama u korist spoljnih igrača. Svi testovi se mogu oceniti kao pouzdani i valjane za košarkaše juniore. LAT se pokazao najpogodnijim za procenu CODSa mladih košarkaša, uz najbolju diskriminaciju igrača prema pozicijama u timu.

Ključne reči*: Brzina promene pravca, mladi košarkaši, pouzdanost, valjanost, razlike prema poziciji*

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Research article

THE ROLE OF FOOTBALL IN THE GREEK POST WAR SOCIETY THROUGH THE PRISM OF ANDREAS FRANGIAS' NOVEL *PEOPLE AND HOUSES*

UDC 796.332(495)(Andreas Frangjas)

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Abstract. *The aim of this paper is to examine the role of football in the lives of the novel's characters, in what way football is represented in Greek society in the early post war period, as well as to which extent this role is similar to the role of football in current society. It turned out that that role was extremely big, football was the only possibility for entertainment and relaxation, but also much more than that. Football matches were a place of gathering and strengthening of unity, an opportunity to belong to the community and to be accepted, but also a source of faith and hope for a better future and a place where the people could still win with the same zeal with which they looked at war victories. Nowadays, fan enthusiasm and belonging to a team are equally pronounced, but football now shares its social role from the post-war period with other sports that have become accessible to the public. The fact is, however, that no other sport has surpassed the love and passion for football.*

Key words: *Football, Literature, Greek Post-War Society*

INTRODUCTION

Andreas Frangias is one of the most renowned Greek post-war novelists. He has published four novels that cover four decades of the Greek post-war society. His first novel, *People and Houses*, features a realistic description of life in one of Athens' suburbs immediately after World War II. The lives and destinies of numerous characters that inhabit the same neighborhood are intertwined in the novel and it is difficult to say who the protagonists are.

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Poverty and unemployment are the main common characteristics of most families. Difficult life circumstances have led to distance and isolation between the people, but there is still one thing that unites the inhabitants of the suburb every Sunday afternoon. It is football. During the whole week it is the only bright thought that they have except from work and money. They are looking forward to Sunday because they will go to the pitch, be together with friends and support the local team. If they have luck the team will win and there will be reason for joy in their lives. If the team loses they will be sad, but a new Sunday will bring new hope.

Many people today could identify with this description, but to what extent is the role of football in today`s society equal to its role in the post-war period? Is this role more important now, or was it more important then? The realistic approach that Andreas Frangias takes in his novel, especially the relationship that the characters in the novel have to football, gives valuable information about the significance of football in the 1940s and it is our aim in this paper to compare it with the role that the football has today. Since the novel is fully realistic, we can consider it a faithful source of information.

The aim of this paper is to examine the role of football in the lives of the novel's characters, in what way football is represented in Greek society in the early post war period, as well as to which extent this role is similar to the role of football in current society.

THEORETICAL CONSIDERATIONS OF THE PROBLEM

Andreas Frangias is a rewarded and renowned author, but there are not many studies of his work. As far as the studies of his first novel are concerned, in some of them there are no references to football, while in some others it plays an important role. Our opinion is that its role is very important and in this paper we will examine whether it is so.

The plot of the novel starts on Sunday, which is the day for football. At the very beginning, on the fourth page of the novel, the reader gets acquainted with the importance of football. The author describes that the pitch is ready from the morning and that everyone who cares about the neighborhood says they have to win that day. Their team has lost several previous games and this time they have to win because if they lose again they will be considered fools. "We necessarily have to win", is a thought that we find without knowing to whom it belongs, but it seems to be the thought of the whole neighborhood (Frangias 2002:12). From the first pages of the novel it is made clear that indifference towards football is not tolerated. It is considered almost an insult to the whole neighborhood, as well as proof that something is wrong with the person who is indifferent.

Argiris, who could be considered the main character, even though it is difficult to decide whether there are protagonists or not, seemingly has different thoughts about winning. His opinion is that it is good to win at every game, but everything has its right time. Though, as the reader finds out later, his situation is quite similar to the neighborhood team's situation. He is unemployed and has failed several times to find a job. He is waiting for someone who had promised to help him and the statement that this time the neighborhood has to win the game is actually about him not being able to stand failing once more. He tries to comfort himself that it is not yet the right time, but deep inside he is desperate about not being able to earn money.

Argiris does not seem to pay much attention to football, and he explains the reason why. He believes that one must have a secure job in order to be able to care about games and championships (Frangias 2002:10). He feels very lonely, as if he is stigmatized in

some way and expelled from the community. He sees that all the people who are going to watch the game have something in common, they have a job, and he has no right to go and try to be with them. The way he sees it, attending the football game means being accepted by the community and being a part of the whole. There are certainly many unemployed spectators, but Argiris' thoughts reflect his inner psychological state, his feeling that he is unworthy and that he is not allowed to have any enjoyment in his life. He believes that his unemployment is his stigma and that no one wants to be near him.

The arrival of the other team players further emphasizes Argiris' condition through the contradiction of his and their mood. The players are cheerful and self-confident, they are singing and waving their orange jerseys. Argiris' mind is dark and occupied with thoughts about the closed factory. Not only does he never sing, but he hardly ever talks, even to his wife. He remembers that a long time ago his wife used to sing, but those days are long gone.

It is obvious even from the first pages of the novel that football is equated with life and there are moments in which the reader cannot know whether the references in the text are about football or life in general. The author constantly mixes football with Argiris` condition and general situation in the afterwar society: "Things are difficult. If the big factory remains closed it does not mean that we have lost everything. The boys know how to play tough", claims the author. The football game equals the game of life. It is so intertwined with people and their lives that they use the same words and have the same thoughts about their own life and football.

The players of the local team are respected. They are considered brave and capable of controlling the situation. If they win, they are admired and adored. They are determined to win no matter the cost and they are devoted to their goal. It is obvious not only from the reactions on the pitch, but also in a scene when Kosmas, a young man from the neighborhood, talks to Georgia, Argiris wife. He says that someone has won and she comments that it was someone who did not get afraid, having in mind her husband who has not managed to find a job yet.

The best football player in the neighborhood is Ilias, but he is determined not to play anymore. He says that football is only for Sundays and that he wants to make something of his life. He does not like the pressure of people`s expectations from him. He is the best and they all expect him always to win. He feels that they like him because he wins for them and not because of who he truly is. When he decides to stop playing, he is considered a traitor and no one wants to talk to him. Even his sister Olga expects him to be strong so that he can give her strength to fight her illness.

For the inhabitants of the neighborhood winning in football means that there is hope for a better future and the changes they are waiting for. Ilias knows that, he is completely aware that football is not just a game for them, and he cannot stand the responsibility of playing an important role in winning or losing. He says that the crowd was shouting "as if they were asking for something much bigger, more important than just a goal" (Frangias, 2002:189).

Football is used by the author even with the character who never went to the pitch. The character of Ilias` sister Tasia is best reflected through her attitude towards football. She can either be proud because the crowd is shouting with joy, for Ilias has scored a goal, or she can say that he is worth nothing because he is only good at football and all he cares about is being supported by the crowd. Her attitudes are very changeable and depend on her mood.

Football also helps the author emphasize the false communication between the members of the family. Ilias is sad because neither of his sisters have ever come to see him play and support him. On the other hand, the sisters are both disappointed that he never took them with him to watch the game and support him. These misunderstandings about football

reflect the loneliness and isolation that happens even inside the families. There is an obvious lack of communication between people and that leads to different bad feelings.

There is one point in the text where the author makes football very different from life in general. At that point he identifies the football game with holidays (Frangias, 2002:180). We cannot completely agree with that statement. If we compare all the references to football in the novel, comparing it with holidays is possible if we have in mind the people`s hope in the days before the game that they will have a good time, that that they will be together, that they will feel joy (but only if the team wins). These are the feelings that are usually expected from holidays. But what people do not expect from holidays and can expect from football in case of losing is stress, agony and the feeling of failure.

References to the role of football in Franigias` novel can be found only in the Greek reviews. Some of the reviewers give a big role to football, and some do not even mention it (all the reviewers who do mention it are named in this paper).

As Vangelis Hatzivasileiou emphasizes, the Sunday football games are the only way out of the everyday pressure for the inhabitants, even if it is just an illusion that they are out of the everyday reality when they are on the pitch (Hatzivasileiou, 2002: 98). People carry their worries everywhere and they just seemingly get rid of them while they are watching football. If anything goes wrong in the game, they are immediately reminded of their problems. But it might be relieving to be able to blame someone else for failure and not yourself.

Takis Karvelis agrees with Hatzivasileiou`s statement and adds that it is the only way out of everyday problems in a difficult life in which there is no communication between people (Karvelis, 1988:12).

A deeper insight in the importance of football is given by Kostas Papageorgiou (Papageorgiou, 2000). Since the novel was written about the period just after the Second World War, he compares the heroes of the football game with the heroes from the past war. Papageorgiou believes that the color of the clothes that the players wear, the blue color of the Greek flag, tends to make this story national, not just about that concrete neighborhood. After four years of war, people suddenly found themselves in the peace they were fighting for, but it was not as they expected and hoped for. They are poor, their life is meaningless and they cannot remember how to be cheerful again. Football gives them an aim higher than just providing food. Football champions are equated with the ethnical heroes and their achievements become legendary. The pitch is almost a holy place, like a church, and the importance of victory in the game is abnormal, a matter of life and death. The pitch does not have regular dimensions, it actually has no borders, it covers the whole neighborhood and goes even farther. The results are of extreme importance for the inhabitants, as if their lives depend on them.

Football is a substitute for the destroyed faith in something bigger. This faith is destroyed for the people of the neighborhood, but they represent the whole nation. They have to win in the game, because it seems to be the only victory that they can achieve and that could make them feel worthy and good. Many inhabitants are unemployed and that makes them feel unworthy. Football is the only light in their lives in that period.

If a man wants to be accepted in the society, he must show interest in football, he must talk about it, feel happy if the team wins and sad if it loses. The rejection that Ilias meets from all the people is equal to the rejection he would get as a traitor in the war.

Papageorgiou almost poetically compares the pitch to an oasis, and a colorful island in the sea of problems that are constantly present and almost impossible to solve.

Babis Klaris emphasizes that the two main themes in the novel are unemployment and football, as if those were the only contents of the lives of the people from the neighborhood (Klaris, 1956). Karvelis agrees with the important role of football and notices that the only things people are talking about are work, the factory and football (Karvelis, 1988: 12).

What Dimitris Kokoris claims about the role of football is that it is not a way for people to cover up their problems, but it reflects their problems like a mirror. A very important role of football is to unite people who are divided by unemployment – those who work do not seem to have much in common with those who do not. The unemployed are generally equated with unworthiness, while during the football game they are all the same (Kokoris, 2009: 56).

As he states, the fact that the main character of the novel, Argiris, is completely out of football is quite controversial. He does not go to watch the games, he does not talk about them, and does not even think about them. Ilias' rejection is really extreme. He asks the man he does not even know to light a cigarette, but the man refuses to let him do it. He explains that he does not want to know him and that he does not exist for them anymore. When Nikos, a young new player, plays well, people say that he saved the team, but it seems as if he has saved the whole community. That is because he saved the hope for a bright and optimistic future.

Space plays an important role in the novel. Many more details about the role of space in this novel can be found in the study Η συμβολική λειτουργία του χώρου (The symbolic function of space) by Eri Stavropoulou (2001).

The people are mostly confined to their houses or the factory. Going out to the pitch, even though it is a closed space again, in some way reflects that people still have the power to do something unusual in their lives, to do something because they want to, not because they have to. The game of football is actually equated with freedom and with the possibility of choice. In the poor neighborhoods of the post war society, it is probably the only thing in the people`s lives that allows them to feel like free human beings.

CONCLUSION

As shown above, football is not only a tool used by the author to construct the characters and the plot, but a very important component of life in the Greek post-war society. It is very important in today`s society as well, but not as important as it was then.

The main reason for that is the fact that today`s society offers many other opportunities for relaxation, fun and avoiding the everyday routine and problems, whereas in the post-war years the opportunities were limited to football.

What has not changed is the people`s need to have something that can occupy their thoughts and make them feel part of a whole, make them feel accepted and not alone.

The football players are still heroes, they are respected and adored. The decision that Ilias made to leave football and go to school would be unusual today, because today`s good players earn a lot of money. Their status has changed from amateurs to professionals.

We tend to say that today football is the most important unimportant thing in life, but the impression from the novel is that in those years it was not so unimportant. It was a very important component of everyday life and in many ways the important things from life were mirrored on and around the pitch.

Nowadays people have many choices as to which games and matches to go to, but still the magic of football attracts the majority of spectators.

It offers, today as before, a feeling of unity, of breaking the barriers, of overcoming personal abilities, of being capable to change changes, of advancing in life, of being stronger, braver and, usually, happier than in the everyday routine. The football was and still is the symbol and the proof of the possibility to create the life you really want and from that point of view it was and still is necessary in every society.

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ULOGA FUDBALA U GRČKOM POSLERATNOM DRUŠTVU KROZ PRIZMU ROMANA *LJUDI I KUĆE* ANDREASA FRANGJASA

Cilj rada bio je da se ispita uloga fudbala u životu likova romana, mere i načina zastupljenosti fudbala u grčkom društvu u ranom posleratnom periodu, kao i u kojoj meri je uloga fudbala u grčkom posleratnom društvu slična ulozi u sadašnjem društvu. Pokazalo se da je ta uloga bila izuzetno velika, fudbal je bio jedina mogućnost razonode i opuštanja, ali i mnogo više od toga. Fudbalske utakmice su bile mesto okupljanja i jačanja zajedništva, mogućnot da se pripada zajednici i bude prihvaćen, ali i izvor vere i nade u bolju budućnost i mesto na kojem se i dalje moglo pobeđivati sa jednakim žarom sa kojim se gledalo na pobede u ratu. U današnje vreme navijački žar i pripadnost timu jednako su izraženi, ali svoju društvenu ulogu iz posleratnog perioda fudbal sada deli sa drugim sportovima koji su postali pristupačni publici. Činjenica je, međutim, da ljubav i strast prema fudbalu ni jedan drugi sport nije nadmašio.

Ključne reči: *fudbal, Andreas Frangjas, grčko posleratno društvo*

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Narrative review article

SPORTS AND EXERCISE MEDICINE IN THE COVID-19 ERA - LET'S MAKE IT A GOOD MARATHON RUN

UDC 61: 796/799
61 (COVID-19)

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Abstract. *The aim of this short narrative review is to investigate the role of sports and exercise medicine (SEM) in managing the current and future pandemics. The coronavirus outbreak caught the whole world by surprise and very quickly imposed the long run ahead of us, changing every aspect of modern living. Being primarily a health crisis, the COVID-19 pandemic placed the biggest strain on the medical community and science. Our understanding of the new circumstances is constantly being updated with new scientific data and medical and other professions directly dealing with the pandemic has to provide the best available (evidence-based) approach. SEM expertise has a huge impact on population's general health and its role in dealing with COVID-19 and future pandemics has to be recognised in several aspects. The multidisciplinary, prevention-orientated, and structured approach of SEM can be crucial for health-oriented community changes.*

Key words: *COVID-19, Physical Activity, Health, Prevention*

INTRODUCTION

The coronavirus outbreak caught the whole world by surprise and very quickly imposed the long run ahead of us, changing every aspect of modern living. Being primarily a health crisis, the COVID-19 pandemic placed the biggest strain on the medical community and science. It is now clear that COVID-19 is here to stay and that prevention is the only effective measure we can take until an efficient and safe vaccine is ready. Like in every major crisis, dealing with it creates new opportunities for society to develop, evolve and educate (Hughes et al., 2020).

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The aim of this short narrative review is to investigate the role of sports and exercise medicine (SEM) in managing the current and future pandemics.

THEORETICAL CONSIDERATIONS OF THE PROBLEM

COVID-19 is a multi-organ disease that can affect the lungs, heart, kidneys, nervous system, liver etc. (Zaim, Chong, Sankaranarayanan, & Harky, 2020). The important aspect of COVID-19 is that in some cases (about 10 % of patients tested positive for SARS-CoV-2 virus) the results in chronic presentation are also known as post-acute or long COVID. The prolonged form of the disease requires adequate evaluation and a close follow-up. The most common symptoms are a cough, low grade fever, and fatigue, followed by shortness of breath, muscle pain and weakness, chest pain and, headaches. A recent study on long COVID-19 acknowledged the importance of gradual return to physical activity (PA) and work using a general population, structured and individualized rehabilitation program - four to six weeks of light aerobic exercise (Barker-Davies et al., 2020; Greenhalgh, Knight, A'Court, Buxton, & Husain, 2020). Cardiac involvement and eventual deficit can be common in previously hospitalized patients according to a JAMA study and its cardiovascular magnetic resonance (CMR) findings (Puntmann et al., 2020). In a cohort of elite athletes post COVID-19 myocardial inflammation (CMR confirmed) was present even in some asymptomatic COVID-19 positive athletes (Rajpal et al., 2020). These findings suggest that adequate health pre-participation evaluation (PPE) of physically active individuals must be warranted (Wilson et al., 2020).

The scope of a pre-participation clinical exam is not easy to determine especially in times when health systems of individual countries are under the burden of a pandemic. At the same time, pandemic-induced lower PA levels among the general population and any unjustified post-PPE restriction of PA could be detrimental to individual and population health (World Health Organization, 2020). SEM professionals should be able to apply their expertise in an individual, structured and gradual approach when evaluating and preparing athletes and other physically active individuals for return to the field of sports and exercise. Special concern should be made for those with persistent symptoms, severe clinical presentation and those involved in high intensity work and exercise load. According to the recently published European Cardiology Association Guideline on Sports Cardiology and Exercise in Patients with Cardiovascular Disease, return to sport participation should be a joint decision of the athlete/patient and attending physician (Pelliccia et al., 2020).

SEM needs to adapt its practices to limited recourses and preventive measures – risk stratification, daily monitoring of elite athletes, remote assessment and field testing are valuable tools and should be developed further (Freeman & Eykelbosh, 2020; Dijkstra et al., 2020). It is important for the challenge of COVID-19-induced regular follow up and health evaluation of athletes and other physically active individuals to be managed in a scientifically sound manner. Available International Olympic Committee guidelines on reporting epidemiological data on injury and illness in sport (Bahr et al., 2020) may provide a uniform approach and future data comparison.

As stated earlier, prevention is key for the current fight against COVID-19. In sport settings, SEM professionals are the most responsible for epidemiological measures and virus transmission control. Their expertise in injury and illness prevention programs should allow good understanding of the present situation (Bahr & Krosshaug, 2005;

Jacobsson & Timpka, 2015; Drew et al., 2017). The same methods of continuous education, quality control and structured programs should be applied and scientifically evaluated (Bizzini & Dvorak, 2015). The recently published Infectious Diseases Outbreak Management Tool for endurance of mass participation sporting events helps competition risk assessment and encourages the use of sports bodies' expertise with that of the local and regional public health system (Adami et al., 2020).

The SEM role in dealing with the COVID-19 crisis goes beyond virus transmission control. The COVID-19 clinical presentation of the patients previously diagnosed with some of the most common chronic non-communicable diseases tends to get more severe and more often requires hospitalisation and intensive care (World Health Organization, 2020). Regular PA can remove 6-10 % of major chronic non-communicable diseases globally (Lee et al., 2012). SEM involvement in global health can be crucial for control of inevitable future pandemics. Physical fitness is a good predictor of general health and adjuvant treatment in many chronic conditions. Further development and promotion of structured and regular PA requires enrolment of appropriately trained SEM professionals (Armstrong, Brubaker, Otto, & Whaley, 2005). Efforts should be made to develop structured and evidence-based educational programs for the field of SEM globally. Primary, secondary and tertiary prevention through regular PA can be of crucial interest for the future control of the world's health (World Health Organization, 2018).

Good control of the ongoing pandemic requires a multidisciplinary approach and team effort. SEM is a good example of several medical and sports disciplines working together. Additionally, application of advanced technologies for remote assessment and doping testing of professional athletes can be a valuable tool for the general population as well (Dijkstra et al., 2020; Pitsiladis, Muniz-Pardos, Miller, & Verroken, 2020). Professional sport with its economic impact plays a significant role in improving community health. Media coverage of sporting events has a great potential for promotion of PA and healthy life habits (Mann, Clift, Boykoff, & Bekker, 2020). New aspects of SEM expertise that emerged during the ongoing pandemic crisis should be scientifically evaluated and structured in consensus statements and relevant guidelines. Good examples are the recently published remote health assessment review and advanced methods for doping testing (Dijkstra et al., 2020; Pitsiladis et al., 2020). Furthermore, during the lockdown, an increasing number of individuals started structured exercise with sport patterns like walking, running, biking etc., making the role of a SEM expertise even more relevant for the COVID-19 crisis (Ding et al., 2020).

CONCLUSION

COVID-19 is here to stay and the fight against it very quickly evolved from fast solutions (lockdown) to a long distance, Ironmen run. Our understanding of the new circumstances is constantly being updated with new scientific data and medical and other professions directly dealing with the pandemic has to provide the best available (evidence-based) approach. SEM expertise has a huge impact on the population's general health and its role in dealing with COVID-19 and future pandemics has to be recognised in several aspects. The multidisciplinary, prevention-orientated, and structured approach of SEM can be crucial for healthoriented community changes.

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MEDICINA SPORTA I VEŽBANJA U COVID-19 ERI - NAČINIMO OD TOGA DOBRU MARATONSKU TRKU

Cilj ovog kratkog narativnog pregleda je da istraži ulogu sporta i vežbanja (SEM) u upravljanju sadašnjim i budućim pandemijama. Izbijanje koronavirusa iznenadilo je čitav svet i vrlo brzo nametnulo dugoročnu borbu koja nam je promenila svaki aspekt savremenog života. Budući da je u pitanju prvenstveno zdravstvena kriza, pandemija COVID-19 nametnula je najveći pritisak na medicinsku zajednicu i nauku. Naše razumevanje novih okolnosti neprestano se upotpunjuje novim naučnim podacima, a medicinske i druge struke koje se direktno bave pandemijom moraju da pruže najbolji dostupan (zasnovan na dokazima) pristup. SEM ekspertiza ima ogroman uticaj na opšte zdravlje stanovništva i njegova uloga u suočavanju sa COVID-19 i budućim pandemijama mora se da prepozna kroz nekoliko aspekata. Multidisciplinarni, preventivno orijentisani i strukturirani pristup SEM-u može da bude presudan u zdravstvenim promenama zajednice.

Ključne reči*: COVID-19, fizička aktivnost, zdravlje, prevencija*

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Research article

RELIABILITY OF TESTS FOR SPEED AND AGILITY ASSESSMENT IN CADET BASKETBALL PLAYERS

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Abstract. *The aim of this research is to determine whether the Illinois test (IL), T-test (Tt), 4x5m Shuttle run (4x5m), 20 m Sprint (S20m), 10 m Sprint (S10m) are reliable tests in assessing the speed and agility of cadet basketball players. The strategy of this research involved a traditional quantitative approach to research with a correlation studies design. The total sample consisted of 38 male participants. The mean age of the participants was -AGE=16.03 years, body height-BH=183.5 cm; body mass-BM=74.1 kg; Body Mass Index-BMI=22.08 kg/m^2. The most reliable agility test when performing without a ball is IL_{NB}, while less reliable are Tt_{NB} and the $4x5m_{NB}$, both without a ball. A reliable test that is performed without a ball to assess the speed of a cadet basketball player is the $S10m_{NB}$. On the other hand, all speed and agility tests when performed with a ball are reliable for testing cadet basketball players. The proposed speed and agility tests have proven to be reliable for cadet basketball players.*

Key words: *Illinois test, T-test, 4x5m Shuttle Run, Sprint*

INTRODUCTION

There are many theories of motor abilities in which speed, as well as its structural elements, plays a part (Kukolj, 2006; Petrović, 2014; Nikolić, Berić, Kocić, Daskalovski, 2017). The concept of maximum human speed contains maximum speed of human motion: a) in the shortest time interval; b) at a minimum external load (minimal exertion of muscle force); and c) in the conditions of minimal requests from the aspect of complexity i.e., coordination (Petrović, 2014).

There are many definitions of agility, and one of them indicates that agility is the fastest possible movement in a curvilinear path (Petrović, 2014). In many studies agility is any

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dynamic movement that involves a change in body position (Draper & Lancaster, 1985; Fulton, 1992; Hastad & Lacy, 1994; Sheppard & Young, 2006). Agility represents a concept derived from force-velocity, velocity-time and velocity-complexity relations (Petrović, 2014).

Sheppard and Young (2006) define agility as whole-body movements with changes in speed and direction that are performed in response to a particular impulse. There are two basic factors that define agility: perceptual and decision-making factors and change in direction of speed, as well as multiple sub-factors (Young, James, & Montgomery, 2002; Young & Farrow, 2006). It should be added that running technique has an important role in performed tests with a change of direction and speed (Sayers, 2000; Bompa & Haff, 2009). Agility is often divided to predetermined changes in direction of speed and where the direction of movement is performed in response to a given impulse (Scanlan et al., 2016).

There are widespread testings of speed and agility in various sports (Little & Williams, 2003; Leone, Comtois, Tremblay, & Léger, 2006; Gabbett, Kelly, & Sheppard, 2008; Spasić, Krolo, Zenić, Delextrat, & Sekulić, 2015). Generally, speed and agility tests can be the Illinois test, T-test, 4x5 m Shuttle run, Zig-Zag, 20 m or 10 m Sprint, while specific speed and agility tests are modifications of general tests or specially designed tests to assess the specific abilities of athletes in various sports disciplines.

Speed and agility have been the subject of a lot of research in basketball (Jakovljević, Karalejić, Pajić, Macura, & Erculj, 2012; Delextrat, Grosgeorge, & Bieuzen, 2015; Gil et al., 2015; Yanci et al., 2015), but it remains unknown whether the previously mentioned tests are reliable for testing cadet basketball players.

The aim of this research is to determine whether the Illinois test, T-test, 4x5m Shuttle run, 10m Sprint, 20m Sprint are reliable tests in assessing the speed and agility of cadet basketball players.

METHODS

Research Design

The strategy of this research involved a traditional quantitative approach to research with a correlation studies design. The correlation was calculated between the test and retest, as well as between separate tests performed with and without a ball.

Sample

The total sample size was 38 male participants. The first testing (Test), conducted in the first week, included 38 participants, while the second testing (Retest), conducted seven days later, included 33 participants. In both tests the same participants were tested. The sample dropout rate is 5 participants. The average age of the participants was Age=16.03±0.49 yrs, body height - BH=183.5±6.15 cm, body mass - BM=74.1±9.93 kg; Body Mass Index - BMI=22.08±2.16 kg/m^2 (Mean±SD). All of the participants have practiced basketball for an average of 2 years and 6 months, 5-7 times a week. The participants are members of two basketball clubs, competing in a league organized by the Basketball Federation of Serbia on the territory of the City of Belgrade. The study was conducted in accordance with the tenets of the Declaration of Helsinki.

Testing procedures

In this study two basic variables were examined - the speed and agility of cadet basketball players. Speed was tested in 4 tests, while agility was tested in 6 tests. The order of the tests was as follows:

The set of tests to estimate speed:

1. $S20m_{NB}$ - 20m Sprint without a ball; 2. $S20m_{B}$ - 20m Sprint with a ball; 3. $S10m_{NB}$ - 10m Sprint without a ball; 4. $S10m_{B}$ - 10m Sprint with a ball.

The set of tests to estimate agility:

1. IL_{NB} - Illinois test without a ball; 2. IL_{B} - Illinois test with a ball; 3. Tt_{NB} - T-test without a ball; 4. Tt_{B} - T-test with a ball; 5. $4x5m_{NB}$ - 4x5m Shuttle run without a ball; 6. $4x5m_{B}$ - 4x5m Shuttle run with a ball.

Each participant had two attempts per test. The better result was taken for data analysis. The tests were conducted one after the other. Before each test, the participants were given clear instructions on how to perform the test. The space was specifically adapted for this type of testing. Time was measured for the same person in the test and retest. After warming up the participants performed the tests. Between each test there was a break of 3 minutes. The order of participants during the testing was the same in the test and retest. The measurement equipment used in this research was: a Beurer PS 240 digital scale, body height meter, Rucanor stopwatch 12, cones, and aMolten dolphin whistle.

Statistical analysis

In this study, the basic descriptive statistics (Mean, SD, Min, Max) for all the studied variables were calculated. The Pearson correlation coefficient (r) was calculated in order to show the relationship between the measured variables in Test-Retest. Also, Pearson's correlation coefficient was calculated to indicate the relationship between tests performed without a ball and tests performed with a ball. The threshold of statistically significant statistical difference stood at a 95% probability level, $p=0.05$. All statistical procedures were carried out by the Microsoft® Office Excel 2007 and the SPSS for Windows, Release 17.0 (Copyright © SPSS Inc., 1989-2002)

RESULTS

Table 1 shows the basic descriptive statistics, mean (M), standard deviation (SD), minimum (min) and maximum (max) values, as well as the difference in mean values (difference, s) in the Test and Retest. Also, the studied variables of the reliability of the tests are shown.

Table 2 shows the relationship between the results obtained in the Test-Retest. This relationship was investigated using the Pearson correlation coefficient. A strong correlation was calculated within all the variables in the Test-Retest, except for the $S20m_{NB}$ test.

A strong correlation was found between the following tests: IL_{NB} & RE_IL_{NB}, $r=0.859$, $p<0.01$; IL_{B} & RE_IL_{B}, $r=0.838$, $p<0.01$; Tt_{NB} & RE_Tt_{NB}, $r=0.883$, $p<0.01$; T_{B} & RE_T_{B}, $r=0.817$, $p<0.01$; $4x5m_{NB}$ & RE_4x5m_{NB}, $r=0.853$, $p<0.01$; $4x5m_{B}$ & RE_4x5m_{B}, $r=0.871$, $p<0.01$.

A lower correlation was found between the following tests: $S10m_{B}$ & RE_S10m_{B}, $r=0.737$, $p<0.01$; $S20m_{B}$ & RE_S20m_{B}, $r=0.617$, $p<0.01$; $S10m_{NB}$ & RE_S10m_{NB}, $r=0.576$, $p<0.01$, and no statistically significant correlation was found between the Test - Retest in maximum speed testing at 20 m without a ball $S20m_{NB}$, $r=0.245$, $p>0.05$.

Table 1 Descriptive indicators of tested variables

Variables	Tests	Measurement	Mean±SD (s)	%cV	Min	Max	Difference (s)
Speed	$S20m_{NB}$	Test	3.37±0.24	7.12	2.79	3.89	0.03
		Retest	3.34±0.29	8.68	2.25	3.89	
	$S20m_{B}$	Test	3.54±0.26	7.34	3.04	4.14	0.07
		Retest	3.47±0.26	7.49	2.95	3.95	
	$S10m_{NB}$	Test	2.05±0.20	9.76	1.67	2.5	0.05
		Retest	2.00±0.18	9.00	1.72	2.36	
	$S10m_{B}$	Test	2.13±0.18	8.45	1.79	2.54	0.08
		Retest	2.05±0.18	8.78	1.72	2.37	
Agility	IL_{NB}	Test	16.07±0.60	3.73	15.05	17.38	0.00
		Retest	16.07±0.68	4.23	14.93	17.45	
	IL_{B}	Test	16.82±0.83	4.93	15.57	18.53	0.44
		Retest	16.38±0.74	4.52	14.91	18.03	
	Tt_{NB}	Test	10.82±0.60	5.55	9.42	12.17	0.17
		Retest	10.64±0.61	5.73	9.11	11.97	
	Tt_{B}	Test	11.42±0.64	5.60	10.07	12.3	0.28
		Retest	11.14±0.61	5.48	9.69	12.16	
	$4x5m_{NB}$	Test	6.77±0.46	6.79	5.91	7.57	0.01
		Retest	6.76±0.65	9.62	5.64	8.16	
	$4x5m_{B}$	Test	6.99±0.61	8.73	5.96	8.05	0.02
		Retest	6.97±0.79	11.33	5.70	8.67	

Legend: $S20m_{NB}$-20m Sprint without a ball; $S20m_{B}$-20m Sprint with a ball; $S10m_{NB}$-10m Sprint without a ball; $S10m_{B}$-10m Sprint with a ball; IL_{NB}-Illinois test without a ball; IL_{B}-Illinois test with a ball; Tt_{NB}-T-test without a ball, Tt_{B}-T-test with a ball; $4x5m_{NB}$-4x5m Shuttle run without a ball, $4x5m_{B}$-4x5m Shuttle run with a ball; RE-Retest; r-Pearson correlation coefficient; Sig.-statistical significance *p<0.05, **p<0.01

Table 2 Basic statistics of correlation analysis in Test-Retest

Test/Retest	Corr.	RE_S20 m_{NB}	RE_S20 m_{B}	RE_S10 m_{NB}	RE_S10 m_{B}	RE_IL_{NB}	RE_IL_{B}	RE_Tt_{N} B	RE_Tt B	RE_4x5m_{N} B	RE_4x5m B
$S20m_{NB}$	*r*	0.245	0.431*	0.430*	.455**	0.374*	0.525**	0.544**	0.664**	0.501**	0.459**
	Sig.	0.170	0.012	0.013	0.008	0.032	0.002	0.001	0.000	0.003	0.007
$S20m_{B}$	*r.*		**0.617****	0.276	0.567**	0.396*	0.346*	0.452**	0.497**	0.255	0.271
	Sig.		0.000	0.120	0.001	0.022	0.049	0.008	0.003	0.152	0.127
$S10m_{NB}$	*r*			**0.576****	0.651**	0.131	0.102	0.598**	0.647**	0.593**	0.615**
	Sig.			0.000	0.000	0.469	0.574	0.000	0.000	0.000	0.000
$S10m_{B}$	*r*				**0.737****	0.172	0.163	0.500**	0.600**	0.530**	0.581**
	Sig.				0.000	0.337	0.366	0.003	0.000	0.001	0.000
IL_{NB}	*r*					**0.895****	0.800**	0.397*	0.344	-0.035	-0.135
	Sig.					0.000	0.000	0.022	0.050	0.847	0.455
IL_{B}	*r*						**0.838****	0.284	0.340	-0.047	-0.100
	Sig.						0.000	0.110	0.053	0.795	0.580
Tt_{NB}	*r*							**0.883****	0.796**	0.484**	0.430*
	Sig.							0.000	0.000	0.004	0.013
Tt_{B}	*r*								**0.817****	0.689**	0.633**
	Sig.								0.000	0.000	0.000
$4x5m_{NB}$	*r*									**0.853****	0.813**
	Sig.									0.000	0.000
$4x5m_{B}$	*r*										**0.871****
	Sig.										0.000

Legend: $S20m_{NB}$-20m Sprint without a ball; $S20m_{B}$-20m Sprint with a ball; $S10m_{NB}$-10m Sprint without a ball; $S10m_{B}$-10m Sprint with a ball; IL_{NB}-Illinois test without a ball; IL_{B}-Illinois test with a ball; Tt_{NB}-T-test without a ball; Tt_{B}-T-test with a ball; $4x5m_{NB}$-4x5m Shuttle run without a ball; $4x5m_{B}$-4x5m Shuttle run with a ball; RE-Retest, r-Pearson correlation coefficient; Sig.-statistical significance *p<0.05, **p<0.01

Table 3 shows the relationship between the results obtained in tests performed without a ball and with a ball. This relationship is expressed by the Pearson correlation coefficient. The calculated correlation showed statistical significance between all the tests.

Table 3 Correlation analysis between tests performed with and without a ball

Tests	Corr.	$S20m_B$	$S10m_B$	IL_B	Tt_B	$4x5m_B$
$S20m_{NB}$	*r*	**0.421****	0.457**	0.347*	0.546**	0.602**
	Sig.	0.008	0.004	0.033	0.000	0.000
$S10m_{NB}$	*r*		**0.739****	-0.119	0.490**	0.633**
	Sig.		0.000	0.475	0.002	0.000
IL_{NB}	*r*			**0.814****	0.479**	-0.035
	Sig.			0.000	0.002	0.833
Tt_{NB}	*r*				**0.726****	0.456**
	Sig.				0.000	0.004
$4x5m_{NB}$	*r*					**0.847****
	Sig.					0.000

Legend: $S20m_{NB}$-20m Sprint without a ball; $S20m_B$-20m Sprint with a ball; $S10m_{NB}$-10m Sprint without a ball; $S10m_B$-10m Sprint with a ball; IL_{NB}-Illinois test without a ball; IL_B-Illinois test with a ball; Tt_{NB}-T-test without a ball; Tt_B-T-test with a ball; $4x5m_{NB}$-4x5m Shuttle run without a ball; $4x5m_B$-4x5m Shuttle run with a ball; r-Pearson correlation coefficient; Sig.-statistical significance *p<0.05, ** p<0.01

In agility tests the strongest correlation was calculated between the tests $4x5m_{NB}$ & $4x5m_B$ r=0.847, p<0.01, a lower correlation was calculated between the tests IL_{NB} & IL_B r=0.814, p<0.01, while the lowest correlation was calculated between the Tt_{NB} & Tt_B r=0.726, p<0.01. Regarding speed tests, a stronger correlation between $S10m_{NB}$ & $S10m_B$ r=0.739, p<0.01 was calculated than between $S20m_{NB}$ & $S20m_B$ r=0.421, p<0.01.

DISCUSSION

The results of this study show that there is a relationship between the Test and Retest, which confirms the reliability of almost all the tests performed without and with a ball to assess the speed and agility of cadet basketball players. Testing has shown that the proposed tests are reliable for testing the speed and agility of cadet basketball players. When comparing the results of the correlation analysis of the proposed tests, one can see a good reliability of the agility tests when performed without a ball. The strongest correlation was found for the tests IL_{NB} r=0.895, p<0.001; a smaller correlation was found for Tt_{NB}, r=0.883, p<0.001, while the smallest correlation was found for $4x5m_{NB}$ r=0.853, p<0.001. There is study on a slightly older sample of basketball players where the reliability of IL (ICC=0.94) and Tt (ICC=0.98) was confirmed (Asadi, 2016). Also, there are studies involving basketball where the S20m test for speed assessment and the T-test for agility assessment were used at ages 12 and 14 (Jakovljević et al., 2012). Such findings in this and other studies allow for the proposed agility tests to be used for the cadet basketball players. When it comes to speed tests, the $S10m_{NB}$ test has been shown to be more reliable than the $S20m_{NB}$ test. The test in which the relationship between the Test and Retest has not been confirmed is $S20m_{NB}$. However, in the study of Asadi (2016) different results were obtained which indicate the reliability of the S20m test (ICC=0.97), and in the study of

Jakovljević et al. (2012) the S20m test is presented as a test to assess the speed of basketball players aged 12 and 14 years.

Generally, there is consensus that the S10m and S20m tests assess speed. The same speed assessment tests are used in other sports such as: rugby (Gabbett et al., 2008), soccer (Mendez-Villanueva et al., 2011), golf (Hellström, 2008). Based on the criterion relating to theoretical assumptions about speed, the application of the proposed tests in various training studies and practices, and the results obtained from the sample in this study, the hypothesis was confirmed that the S10mNB test is reliable for testing the speed of a cadet basketball player.

Also, agility tests such as the IL, Tt and 4x5m are widely used in agility testing: basketball players (Asadi, 2016; Borović, Rupčić, Matković, Garafolić, & Dadić, 2016), soccer players (Milanović, Sporiš, Trajković, James, & Šamija, 2013) rugby and handball players (Hachana et al., 2013). There is consensus among the authors that the mentioned tests assess agility, and the results obtained in this research confirm the possibility of applying these tests among the cadet basketball players. This confirms the hypothesis that the IL, Tt and 4x5m tests are reliable for assessing the agility of cadet basketball players.

The reliability of all agility tests when performed with a ball has been confirmed. The $4x5m_B$ test has the strongest reliability, while IL_B and Tt_B have slightly lower reliability. Also, the reliability of tests ($S10m_B$, $S20m_B$) for assessing the speed of cadet basketball players when performed with a ball has been confirmed. These findings confirm the basic hypothesis of this research that tests for assessment of agility and speed, which are performed with and without a ball and which have the same movement pattern, are reliable for cadet basketball players.

The agility tests IL and Tt are more reliable when performed without a ball, while the 4x5m test is more reliable when performed with a ball. The findings confirm that speed tests which are performed with a ball have higher reliability than tests performed without a ball. All five tests which are performed with a ball are reliable for testing cadet basketball players.

There is a strong correlation between speed tests as well as between agility tests when performed with and without a ball. It can be concluded that these tests assess the same ability, regardless of whether they are performed with or without a ball. So, when the aim of testing the speed or agility of cadet basketball players is enough to choose one type of test, performed with or without a ball, but which have the same movement pattern. This fact emphasizes the importance of basic movement in understanding and testing speed and agility. Modifying the test, i.e. adding a ball to the basic pattern of movement, does not contribute to a better and more precise examination of the speed and agility of cadet basketball players. This indicates a high degree technique application in this age.

This study showed that the S20m test is not reliable when performed without a ball, while in all the other tests, reliability was determined regardless of whether they were performed with or without a ball. It is possible that this result is a consequence of a measurement error, because the reliability of this test has been confirmed in other studies. The reliability of the $S20m_{NB}$ test should be further investigated in future research.

CONCLUSION

Speed and agility are significant motor abilities for a basketball player. It is necessary to know the level of these abilities of cadet basketball players in order to monitor, improve and organize the training process. The proposed agility and speed tests have been shown to be reliable for testing cadet basketball players.

The most reliable agility test when performed without a ball is the IL, while the Tt and 4x5m tests are slightly less reliable. When it comes to speed tests, when performed without a ball, the S10m test is more reliable, while the S20m test should be checked in future research. On the other hand, all speed and agility tests when performed with a ball are reliable for testing cadet basketball players.

This research confirmed that tests which basically have the same movement pattern assess the same ability. The strong correlation between tests performed with and without a ball justifies this thesis. Each test, observed separately, performed without a ball, had a strong relation with the test performed with a ball.

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POUZDANOST TESTOVA ZA PROCENU BRZINE I AGILNOSTI KOŠARKAŠA KADETA

Cilj ovog istraživanja je da se utvrdi da li su Illinois test (IL), T-test (Tt), 4x5m Šatl trčanje (4x5m), 20 m Sprint (S20m), 10 m Sprint (S10m) pouzdani testovi u proceni brzine i agilnosti košarkaša kadeta. Strategija ovog istraživanja podrazumevala je tradicionalni kvantitativni pristup istraživanju sa korelacionim studijskim dizajnom. Ukupan uzorak sastojalo se od 38 muških ispitanika. Srednja starost ispitanika bila je -AGE = 16.03 godina, telesna visina-BH=183.5 cm; telesna masa-BM=74.1 kg; Indeks telesne mase-BMI=22.08 kg/m^2. Najpouzdaniji test agilnosti pri izvođenju bez lopte je IL$_{NB}$, dok su manje pouzdani Tt$_{NB}$ i 4x5m$_{NB}$, oba bez lopte. Pouzdan test koji se izvodi bez lopte za procenu brzine kadeta košarkaša je S10m$_{NB}$. Sa druge strane, svi testovi brzine i agilnosti kada se izvode sa loptom pouzdani su za testiranje košarkaša kadeta. Predloženi testovi brzine i agilnosti pokazali su se pouzdanima za košarkaše kadete.

Ključne reči*: Illinois test, T-test, 4x5m šatl trčanje, sprint*

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Research article

RELIABILITY OF TESTS FOR MEASURING ISOMETRIC FORCE OF THE MUSCLES WHILE SHOOTING IN BASKETBALL

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Abstract. *The aim of this research is to determine the isometric muscle force (IMF) of the dominant arm in the position directly before the basketball shooting, and to check test reliability. Fifteen male basketball players (age 17±1 years, body height 185.60±6.31 cm; body mass 78.07±8.56 kg) with at least 5 years of the basketball experience, were subjected to a muscle manual test (shoulder flexion, elbow extension and wrist flexion), using a hand-held dynamometry (HDD). High values of relative reliability are reported in each of the tests (0.79, 0.82, and 0.84, respectively). Cronbach's alpha coefficient indicated the values of reliability during shoulder flexion, elbow extension and wrist flexion range from 0.779, 0.807, 0.848 respectively, presenting the results of the reliability as high. The applied F test provides a statistically significant Intraclass Correlation Coefficient at the level of p<0.001 for each test. Absolute reliability is displayed through the coefficient of variation, and meets the criterion which ranged between 5.6 to 7.8%. HDD was determined to be reliable in terms of measuring IMF.*

Key words: *Manuel Muscle Test, Hand-Held Dynamometry, Biomechanics, Basketball Players*

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INTRODUCTION

The study of muscle force as a motor ability in sports has grown dramatically over the years. The phenomenon of isometric muscle force (IMF) can be estimated in different ways (Marković, Dopsaj, Koprivica, & Kasum, 2018). One of the ways is known in physiotherapy practice as a muscle manual test (MMT). This test qualitatively and directly assesses the magnitude of muscle force, depending on the movement and position of the patient (Bohannon, 2019). For many years, there have been procedures applied to standard movements, justified by plenty of studies and with confirmed metric characteristics. The development of technology enabled highly suitable dynamometers to be used in muscle force assessment in different positions, i.e., depending on which movement is being analyzed, the position of subject varies. Some of the studies have been completed on the basis of the reliability and validity of hand-held and hand grip dynamometers while measuring isometric force magnitude in patients by one or two experienced testers (Bohannon, 1986; Wadsworth, Krishnan, Sear, Harrold, & Nielsen, 1987; Wadsworth, Nielsen, Corcoran, Phillips, & Sannes, 1992; Bohannon, 1998; Awatani et al., 2016).

However, not many scientific papers have dealt with the hand-held dynamometry (HDD) and force assessment upon specific movements in a particular sport. Basketball is one of the most popular sports today. It would have been interesting to further analyse and compare isometric muscle force data obtained through hand held dynamometry testing with other motor abilities, e.g., precision. HDD testing should not be assumed and related to players' performance only, but to injury and time loss prevention. Although, muscle force is not a ruling characteristic while shooting, it is crucial to acknowledge the parameters of the normal function of the upper arm (Diesel, Dana, & Laver, 2020).

Despite the shooting style being specific to each basketball player, levers of the arms fulfill certain biomechanical laws related to the ideal arms position.

The aim of this research is to determine the IMF of the dominant arm in a position directly before the basketball shooting, and to check test reliability.

METHODS

Participants

The participants of the study were elite, adolescent basketball players aged 16 to 18 (17±1 years), with a body height of 185.60±6.31 cm and body mass of 78.07±8.56 kg (Mean±SD). Fifteen (n=15) male players, in good health, with basketball practice experience of at least five years were recruited from a single team. The testers were recruited from the graduates and teachers of the Faculty of Sport and Physical Education, University of Niš. Study procedures were approved by the Faculty of Sport and Physical Education Ethics Committee in accordance with the Helsinki Declaration. All of the participants provided informed consent prior to participation.

Design and procedures

In order to activate the muscles of the upper extremities, the participants completed warm-up exercises for a duration of 10 minutes prior to testing. The starting position of the IMF testing is sitting on a chair without a backrest in order to neutralize the retroactive force in the lower extremities. The participant assumes a shooting position, the one he finds

most suitable and most practiced throughout the years, and without a ball. The tester assumes a stable and comfortable standing position beside the chair in accordance to the established MMT procedure, with an HDD in his palm, and establishes contact with the provided region of the participant's dominant arm. The tester uses his other arm for the fixation (Figure 1). After the voice signal of the tester to start the test by imitating shooting, the participant gently pushes the dynamometer and the tester's arm until he overcomes the threshold defined at 5 kilograms, after which he is notified by the sound signal of the dynamometer to manifest the maximum force in the given time of 3 seconds.

The established interaction between tester and basketball player generates IMF results. Isometric muscle testing is based on a closed kinetic chain principle which implies that force is the same at any point of the chain.

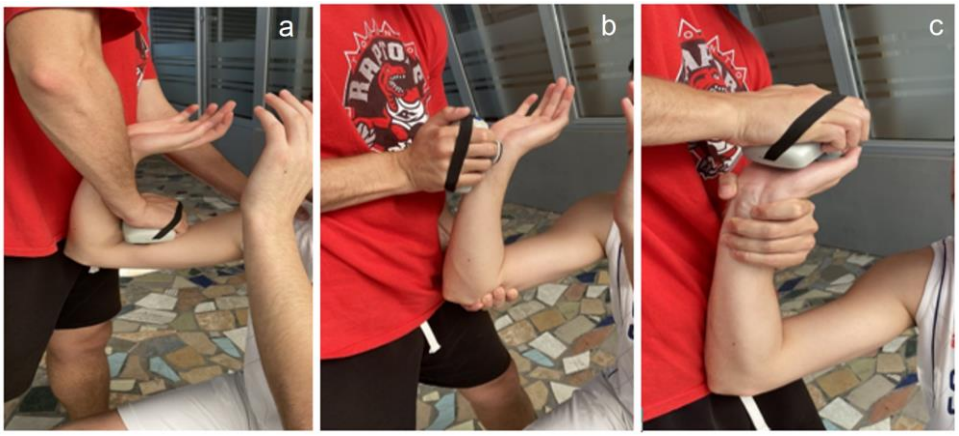

Fig. 1 Setting of the isometric muscle force testing of the shoulder flexors with a fixed proximal part of the upper arm (a); of the elbow extensors with a fixed proximal part of the lower arm (b); of the wrist flexors with a fixed proximal part of the palm (c); with the inclusion of a hand-held device

Both testers and participants performed a couple of pre-trials to become familiarized with the testing procedure. Subsequently, each set (testing of the shoulder flexors+the elbow extensors+the wrist flexors) of the IMF tests is performed three times with a fifteen-minute break between sets. The best score is used for analysis. The measurement procedure is repeated over three successive days, in order to obtain data for further processing and verification of the reliability of the measurement. Visual and verbal feedback on the force curve status is avoided. The dynamometer used in this study was a HDD (Lafayette Instrument Company).

Instruments

IMF was evaluated using a digital HDD, Lafayette Instrument Company, Sagamore, USA (Ribeiro, Cools, & Camargo, 2020).

Statistical analysis

For data processing, the test-retest method was used to determine the reliability of the proposed tests. Along with the basic descriptive statistics and intraclass correlations, the Analysis of variance was calculated to assess the statistical significance of each item. Finally, the Intraclass correlation coefficient, Confidence interval, Cronbach's alpha coefficient for determining the internal consistency of the test, the Coefficient of variation, Typical error, and the Smallest worthwhile change for assessing the usefulness of the test were calculated. SPSS 20 Statistical Package for the Social Sciences version 20.0 (IBM Corporation, New York, USA) was used to analyze the data.

RESULTS

After data acquisition, the best results were extracted for further reliability analysis. Thus, the variability was obtained: best A-B, where A represents the measurement 1-3, and B represents the test 1-3 (testing of the shoulder flexors, testing of the elbow extensors, and testing of the wrist flexors, respectively). Using the Shapiro-Wilk test determined that almost all the variables met the criteria and did not statistically significantly deviate from the normal distribution (Table 1).

Table 1 The Shapiro-Wilk test of the normality

A-B	Shapiro-Wilk		
	Statistic	df	Sig.
Best 1-1	0.906	15	0.116
Best 1-2	0.951	15	0.546
Best 1-3	0.895	15	0.081
Best 2-1	0.936	15	0.339
Best 2-2	0.905	15	0.114
Best 2-3	0.927	15	0.250
Best 3-1	0.969	15	0.848
Best 3-2	0.863	15	0.056
Best 3-3	0.943	15	0.425

Homogeneity of the variance was also tested using Levene statistics. Each of the variables displayed equal variance (the values of Leven statistics were not statistically significant at the level $p \geq 0.05$ (Table 2).

Table 2 Test of the homogeneity of variance

	Levene Statistic	df1	df2	Sig.
Flexion in the Shoulder Joint (kg)	2.980	2	42	.062
Extension in the Elbow Joint (kg)	2.539	2	42	.091
Flexion in the Wrist Joint (kg)	.319	2	42	.729
Angle in the shoulder joint (deg)	.541	2	40	.587
Angle at the elbow joint (deg)	.314	2	40	.733
Angle in the wrist (deg)	.744	2	40	.482

It is known that the manifestation of IMF directly depends on the lever system of the human body. The force produced depends on the angle in particular joints when taking a certain position. Therefore, it was necessary to check the consistency of the hand position when shooting, i.e., to check whether the angles in the actual joints change depending on the trial. For this purpose, hand positions were recorded during the first day of IMF testing, and the angles were calculated by the help of the Kinovea program, Copyright (C) 1989, 1991 Free Software Foundation, Inc. Based on Cronbach's α-coefficient, it can be concluded that the consistency of the shooting angles is evaluated as high (Table 3).

Table 3 Cronbach's Alpha Level of the Reliability

Test	Trial	Mean±SD	Cronbach (α)
Angle in the shoulder joint deg)	1	99.33 ± 8.10	0.904
	2	99.80 ± 8.05	
	3	99.30 ± 6.77	
Angle at the elbow joint (deg)	1	65.06 ± 10.42	0.961
	2	65.13 ± 9.11	
	3	63.07 ± 8.24	
Angle in the wrist joint (deg)	1	139.86 ± 8.70	0.938
	2	139.20 ± 7.69	
	3	141.92 ± 10.96	

Table 4 shows the descriptive and reliability statistics of the IMF testing. High values of relative reliability are reported in each of three tests (Flexion in the shoulder joint, Extension in the elbow joint, and Flexion in the Wrist joint, 0.79, 0.82, and 0.84, respectively). According to Hopkins, Marshall, Batterham, and Hanin (2009) Intraclass Correlation Coefficient (ICC) values ranging from 0.71 to 0.90 are considered high. Furthermore, Cronbach's alpha coefficient reported the magnitude of reliability of the items in each test. According to Darren and Mallery (2003) this coefficient ranges from unacceptable≤0.5; weak=0.51-0.60; suspicious=0.61-0.70; acceptable=0.71-0.80; good= 0.81-0.90; to excellent ≥0.91. It was noticed that the values of reliability in Flexion in the shoulder joint, Extension in the elbow joint, and Flexion in the Wrist joint range from 0.779, 0.807, and 0.848 respectively. Hence, the reliability of these tests is good. The applied F test provides statistically significant ICC at the level of $p<0.001$ for each test. Absolute reliability was displayed using the coefficient of variation (CV) and typical error (TE) (Atkinson & Neville, 1998). The coefficient of variation of 10% is taken as a criterion for accepting internal reliability. It is calculated as the ratio of standard deviation and arithmetic mean multiplied by 100. Table 4 shows that the coefficient of variation ranged from 5.6 to 7.8%, which satisfies the taken criterion. The test efficacy was determined by comparing the typical error (TE) with the least significant change. The Smallest Worthwhile Change (SWC) was determined by multiplying the standard deviation of each measurement by 0.2 (Hopkins, 2004). Since the value of the SWC is lower than the TE, it is concluded that the test score is “marginal”, i.e., insufficiently sensitive. However, it should be taken into account that according to Hopkins, the smallest effect of 0.2 is taken, while any other larger effect (e.g. 0.3) is graded as “good” (this research deals with adolescent athletes who are still in adopting shooting patterns of the motor skills).

Table 4 Descriptive and reliability statistics of the isometric muscle force testing

Test (kg)	Trial	Mean±SD (kg)	ICC (95% CI)	α	p	CV (%)	TE (kg)	SWC (kg)	Rating
Flexion in the Shoulder Joint	1	20.00±3.51	0.79 (0.49, 0.92)	0.779	4.515 p<0.001	7.8	0.59	0.44	Marginal
	2	20.00±2.33							
	3	19.93±2.22							
	In total	19.98±2.29							
Extension in the Elbow Joint	1	20.80±2.65	0.82 (0.56, 0.93)	0.807	5.189 p<0.001	7.3	0.64	0.50	Marginal
	2	20.80±3.47							
	3	21.00±2.62							
	In total	20.87±2.50							
Flexion in the Wrist Joint	1	21.60±2.06	0.84 (0.63, 0.94)	0.848	6.584 p<0.001	5.6	0.49	0.38	Marginal
	2	21.53±2.03							
	3	22.33±2.44							
	In total	21.82±1.91							

Legend: SD=Standard Deviation; ICC=Intraclass Correlation Coefficient; CI=Confidence Interval; α=Cronbach's alpha; p=F Value set at level <0.001; CV=Coefficient of Variation; TE=Typical Error; SWC=Smallest Worthwhile Change=0.2xSD.

DISCUSSION

What distinguishes this study from previous ones are the participants, i.e., the aim of the study. While in previous studies, the sample of participants consisted mainly of patients, and less of healthy athletes and non-athletes, we focused on elite adolescent basketball players and their isometric muscle force testing in the function of sport performance and the results to be achieved.

One of the first articles dealing with reliability of testing certain muscle groups in patients using the MMT and HDD was written by Beasley in 1956. The suggestion was that MMT without HDD in terms of reliability should be taken with consideration in some cases.

Indeed, the usage of the MMT without HDD can represent a potential source of error. Namely, a tester is not able to precisely evaluate the subtle variations in muscle strength (Wadsworth et al., 1987).

And although MMT measurements are quantitatively less precise than HDD measurements, muscle testing is generally dependent on the strength of the tester. Wikholm and Bohannon (1991) determined that tester strength above 120N represents a major determinant of the reliability upon HDD force measurements.

Bohannon and Andrews (1987) tested 6 muscle groups in patients, using the MMT and HDD. Good tohigh inter-rater reliability related to 6 muscle groups was determined, with the authors' note that due to differences in the testers' mean values related to two muscle groups, a further investigation of HDD is needed.

Estimating the muscle force and the reliability of tests using the HDD in healthy participants, Byl, Richards, & Asturias (1988) found intra-rater reliability coefficients to have acceptable values (ranging from 0.833 to 0.957), but interrater reliability coefficients proved to be more variable, ranging from low (0.518) to high (0.840).

Kim, Lim, & Cho (2016) confirmed high degree intra-rater (0.992) and inter-rater (0.949) reliability of the MMT, performed by one or two testers, using a HDD in healthy, non-athletes, who were Korean university students.

In addition, Tudini, Myers, & Bohannon (2019) determined high intra-rater and inter-rater reliability (ICC ranging from .885-.974) and the SWC ranging from 21.1 to 47.6 N in HDD testing of healthy subjects.

The fact that dinamometry measuring is reliable in terms of handgrip strength was proved by Gerodimos (2012) in his study of adult male basketball players.

Another study measuring hand dynamometry and field test performance worth mentioning is that of Gil and associates (2015), and it included wheelchair basketball players. Handgrip strength and the tests measuring ball throwing ability (pass and shooting) are determined to be positively related to the disability class of the participants.

Based on the results of the current study, the reliability of HDD to measure IMF appears to be in line with previous studies.

Hence, a common feature of previous and the current study is that, despite differences in the participant sample (patients, healthy athletes and non-athletes), and more or less sophisticated devices used, the reliability of the measurements could be evaluated as high.

CONCLUSION

A study was conducted on a sample of 15 elite, adolescent male basketball players aged 16 to 18, with the aim of assessing the IMF of the dominant arm in the position directly before the basketball shooting, and to check test reliability. The testing was conducted over three successive days, and the best, i.e., the highest value of the applied isometric muscle force among three trials within each test, was further statistically processed. The HDD presented to be reliable in terms of measuring muscle force.

The application of the MMT using an electronic dynamometer has been in practice for years and there are papers confirming its validity and reliability. However, studies are conducted mostly with patients in physiotherapy practice.

This paper attempts to open a new chapter in the study of muscle strength in situational conditions of sports performance. Further study of the differences (and influences) between the isometric muscle force obtained in the basketball shooting position through HDD testing and other motor abilities is needed.

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POUZDANOST TESTOVA ZA MERENJE IZOMETRIJSKE SILE MIŠIĆA TOKOM ŠUTA U KOŠARCI

Cilj ovog istraživanja je da se utvrdi izometrijska sila mišića (ISM) dominantne ruke u položaju neposredno pred šut u košarci i da se proveri pouzdanost testa. Petnaest košarkaša (starosti 17±1 godina, telesne visine 185.60±6.31 cm; telesne mase 78.07±8.56 kg) sa košarkaškim iskustvom ne kraćim od 5 godina, podvrgnuto je manuelnom mišićnom testu (Fleksija u zglobu ramena, Ekstenzija u zglobu lakta i Fleksija u zglobu ručja), primenom ručne dinamometrije. Visoke vrednosti relativne pouzdanosti zabeležene su u svakom od navedenih testova (0.79, 0.82, i 0.84, tim redosledom). Cronbach-ov alfa koeficijent ukazuje je na vrednosti pouzdanosti tokom fleksije u zglobu ramena, ekstenzije u zglobu lakta i fleksije u zglobu ručja u rasponu od 0.779, 0.807, i 0.848 (tim redosledom), predstavljajući rezultate pouzdanosti kao visoke. Primenjeni F test pruža statistički značajan koeficijent korelacije unutar klase na nivou p<0.001, za svaki od testova ponaosob. Apsolutna pouzdanost je predstavljena koeficijentom varijacije i zadovoljava kriterijum koji se kretao između 5.6 i 7.8%. Ručna dinamometrija predstavljena je kao pouzdana metoda u pogledu merenja ISM.

Ključne reči: *manuelni mišićni test, ručna dinamometrija, biomehanika, košarkaši.*

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Research article

THE CONNECTION BETWEEN THE AGILITY OF ADOLESCENT SOCCER PLAYERS AND THEIR BODY COMPOSITION

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Abstract. *The aim of this study is to determine body composition (BC) factors that influence agility among adolescent soccer players (N=66), in U14, U16, U18 soccer teams of the Topola Sport Club. Agility tests (Dribbling test, Illinois test), Inbody 720 instrument measuring the BC, and Oxa Starter infrared timing gate instrument measuring speed the agility were used. Data are processed by the IBM SPSS Statistics 25 software. In addition to descriptive statistics, a correlation matrix analysis, linear regression and one-way analysis of variance (ANOVA) were also applied ($p<0.05$). A moderate correlation between agility with a ball and without a ball ($r=0.595$) is determined as well as between agility and BC parameters: Skeletal Muscle Mass, Intracellular Water Mass, Protein Mass, Mineral Mass ($r=-0.453$, -0.454, -0.453, -0.417, respectively) while the correlation between agility and Height, Mass, Body Mass Index, Right Leg Lean Mass, Left Leg Lean Mass, Extracellular Water Mass is less than moderate ($r=-0.318$, -0.329, -0.276, -0.332, -0.330, -0.374, respectively). A slight correlation is determined between agility with a ball and BC variables. No correlation was determined between Agility and Body Fat Mass. The influence of BC on agility is lower than expected. Using the scientific based approach and measurements, a complex exercise plan can be made for players and in this way young soccer players can be trained by using tailor-made and post-specified coaching methods.*

Key words: *Agility, Adolescents, Soccer, Body Composition.*

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INTRODUCTION

Agility, a Latin word, has the everyday meaning of: modesty, dexterity, alertness, vitality, speed, and mobility (Bakos, 2007). Agility is most noticeable in sports with *open motor skills*, for example in various ball games and in combat sports. In modern soccer, agility is considered to be the key to success (Koltai, 2018). In sports with *open motor skills*, straight-line running occurs rarely (Bangsbo & Mohr, 2012); on the other hand, random *redirection* or *change of direction* can be observed constantly (Goodman, 2008). There are several definitions in the international literature, but they all agree that it includes a direction of motion changed at maximum speed (Bloomfield et al., 1994). Agility is often characterized by rapid start, stop (Gambetta, 1996), and explosiveness (Baker & Nance, 1999). According to Sheppard and Young (2006), agility is defined as *"a rapid physical activity that involves a change in speed and direction by a stimulus"*. In simplified terms, it is an unpredictable change in speed or direction (Draper & Lancaster, 1985). The ability to *accelerate* and *decelerate* with a change of direction is usually called agility. It is a rapid whole-body movement that involves a change in speed or direction in response to an environmental stimulus. Based on this, agility is much more complex in sports games, consisting of perceptual, decision-making, and change of direction components (Young, Dawson, & Henry, 2015). There are many factors that influence this speed, for example, straight-line sprinting (SS), leg strength, and *reactivity*.

In a soccer match, a change of direction occurs every 2 to 4 seconds, which means that it occurs 1200 to 1400 times throughout the match (Sporiš, Jukić, Ostojić, & Milanovic, 2009). Through the development of finer GPS systems, these changes of direction have become the focus of match analysis (Barnes, 2016). Running performance during soccer matches requires an extensive amount of technical, tactical, psychological and physical effort, including aerobic and anaerobic energy processes, muscular strength, flexibility and agility (Chamari et al., 2004). During a game, low and high intensity periods alternate periodically with short sprints, jumps, and directional changes (Rouissi et al., 2006). The nature of the agility, its characteristics and its connection to other abilities lead to contradictions. The relationship between agility and speed was not clearly substantiated (Young, Hawken, & McDonald, 1996; Buttifant, Graham, & Cross, 2002; Condello, Schultz, & Tessitore, 2013; Milanović et al., 2014). There was no direct relationship between leg strength and agility (Webb & Lander, 1983; Young, James, Montgomery, 2002). Some authors associate agility with coordination skills (Katics, 2015). Agility performance may vary at *different training levels*, but not necessarily those in the highest level achieve the best results (Koltai et al., 2016). Overall, it can be stated that the relationship between agility and different endurance abilities or traditional coordination abilities cannot be clearly demonstrated (Sever & Zorba, 2017).

Agility is independent of the positions occupied in the game (Ruas et al., 2015; Franks & Hughes, 2016), but selecting a position may be significantly influenced by genetic predispositions (Reilly, Bangsbo, & Franks, 2000; Rebelo et al., 2013; Perroni, Vetrano, Camolese, Guidetti, & Baldari, 2015). However, most research does not show significant differences in the selection of players for a given position based on their anthropometric, physical or mental characteristics (Coelho, Figueiredo, Cumming, & Malina, 2010; Fiorilli et al., 2013; di Cagno et al., 2014; Deprez et al., 2015).

In light of the abovementioned, it seems that the two types of agility, agility without a ball and agility with a ball are increasingly seen as distinct, independent, complex

abilities (Koltai et al., 2017). Both agility without a ball and agility with a ball are important in soccer for all players in any position (Németh, 2015). Agility without a ball, in terms of its structure of movement, is mostly related to *horizontal*, defensive roles, while agility with a ball plays an important role in *vertical*, offensive movements.

By examining the validity of the various agility tests, researchers tried to determine the most suitable tests for estimating the agility of the players in different positions (Sporiš, Jukić, Milanović, & Vučetić, 2010; Young & Willey, 2010).

The performance of young athletes is significantly influenced by their body composition. A number of researchers (Post et al., 1997; Bodzsár & Susanne, 1998; Beunen, 2003) have concluded that nutrition is a major determinant of children's development. The amount, quality and regularity of energy intake and the frequency of physical activity are key factors during children's development (Szakály, 2008). According to recent research (Németh & Költő, 2014), the lifestyle of adolescents is characterized by inactivity and unhealthy nutrition. Malnutrition creates a state of deficiency in vital nutrients, altering the body composition of the individual, which causes the individual's physical performance to decline. The body's relative fat content decreases at birth, then increases until puberty and stabilizes in the post-pubertal age. However, in recent decades, the amount of adipose tissue has increased in samples of students (Szakály, 2008). According to Lohman (1992), the optimal body fat content for boys who regularly perform physical activity is between 15% and 16%. The relationship between body composition and physical or physiological performance has been demonstrated from multiple aspects (Prókai et al., 2005; Rowland, 2005; Photiou et al., 2008). In biology and health research studies, the fat to mass ratio is a commonly studied feature, whereas in sports anthropometry, in addition to the amount of fat, the proportion of muscle tissue is also of greater importance (Szakály, 2008). Changes in body composition and physical performance of children and adolescents are closely related (Gyenis, 1975; Eiben & Pantó, 1981; Farmosi & Bakonyi, 1987; Mészáros, Othman, & Szabó, 2001).

According to some estimates, the number of malnourished children and adolescents in Hungary today is between 250000 and 350000 (Mészáros et al., 2001). Proper nutrition also includes regular intake of protein, vitamins and minerals that fully satisfies biological needs.

As a result of normal organic development and workout adaptation, the physique and anthropometric data of athletes of all ages may change significantly. Presumably, players with a lower center of gravity benefit when having to perform quick changes of direction. It would seem evident that athletes with more leg strength are more effective in making quick starts and sudden stops. The role of laterality may manifest in the muscle mass of the two legs.

The aim of this study is to determine body composition factors that influence agility among adolescent soccer players.

METHODS

Participants

The participants in this cross-sectional study consisted of soccer players of age groups U14, U16 and U18, from the Topola Sport Club Junior Academy (Bačka Topola, Serbia). The following players (according to their position in the team) took part in the study: 5 goalkeepers, 17 defenders, 25 midfielders and 19 strikers (N=66). The players participated in

four training sessions per week and in one match during the weekend. The study was conducted during the winter preparation period.

Variables

Body mass index (BMI); Right Leg Lean Mass (RLLM); Left Leg Lean Mass (LLLM); Intracellular Water Mass (IWM); the Extracellular Water Mass (EWM); Protein Mass (PM); Mineral Mass (MM).

Internationally standardized agility tests:

- Illinois Change of Direction Speed Test (ICODT)-with and without a ball;
- T-Test*without a ball;
- TDS Dribbling Test-without a ball, and with a ball using the dominant, and subdominant leg.

The tests were done on a hard sport flooring after a standard warm-up. The better result was considered of the two attempts.

Instruments

The Oxa Starter+ infrared timing gate was used as the measuring instrument for the agility tests.

The gate consists of an infrared antenna-free transmitter and a receiver with an infrared (950 nm) antenna, integrated with a radio transmission unit. The instrument needs a 9V DC power source, and it has a power consumption of 9 to 20 mA. The system is connected to the computer through an USB port. The measuring device consists of five light gates.

Body composition analysis

For this study, the InBody 720 (Biospace Co. Inc., Seoul, South Korea) Bioelectrical Impedance Analyzer (BIA) was used (Nagyváradi, 2017).

Data analysis

The results were encoded, recorded in an Excel table and processed with *IBM® SPSS®* Statistics 25 software. In addition to descriptive statistics, a correlation matrix analysis, linear regression and one-way analysis of variance (ANOVA) were also applied. The significance was set at the $p<0.05$ level.

RESULTS

The study included N=66 young elite soccer players with a span of 6 years in terms of age, split into three age groups (U14, U16, U18). Their average BH was 1.75 meters, with the shortest participant being 1.51 meters and the tallest being 1.98 meters. Their average BM was 64.5 kg with a standard deviation of 11 kg. The average SMM was 32.39 kg, with a standard deviation of 5.85 kg. BFM had an average of 7.09 kg with a standard deviation of 3.59 kg. Accordingly, the participants had a low BMI with an average of 20.91. The sample contained 56 right-footed (85%) and only 10 left-footed players. RLLM averaged 9.16 kg for right leg, and LLLM averaged 9.09 kg for left leg. The combined muscle mass of the two legs averaged 18.25 kg (standard deviation 3.20

kg), IWM averaged 26.38 kg (standard deviation 4.49 kg), EWM averaged 15.68 kg, PM averaged 11.40 kg (standard deviation 1.94 kg), and MM averaged 3.93 kg (standard deviation 0.67 kg).

Table 1 Body composition parameters

N=66	Minimum	Maximum	Mean	Std. Deviation
Height	151.00	198.00	175.09	9.20
Body Mass	37.10	86.70	64.47	10.94
Skeletal Muscle Mass	18.60	45.20	32.40	5.86
Body Fat Mass	1.80	24.60	7.09	3.59
Body Mass Index	15.00	25.80	20.91	2.24
Right Leg Lean Mass	5.34	13.68	9.16	1.61
Left Leg Lean Mass	5.32	13.55	9.09	1.60
Right + Left Leg Lean Mass	10.66	27.23	18.25	3.21
Intracellular Water Mass	15.80	36.20	26.38	4.49
Extracellular Water Mass	9.50	21.60	15.68	2.49
Protein Mass	6.80	15.60	11.40	1.94
Mineral Mass	2.42	5.34	3.93	0.67

Body parameters by age group

One-way analysis of variance (ANOVA) applied to SMM, BMI, PM, MM, RLLM, and LLLM showed a statistically significant difference between the average values of the age groups ($p<0.000$). Values showed a strict monotonous growth in all cases. BFM also exposed an increase between age groups; however, statistically this is not proven ($p=0.493$).

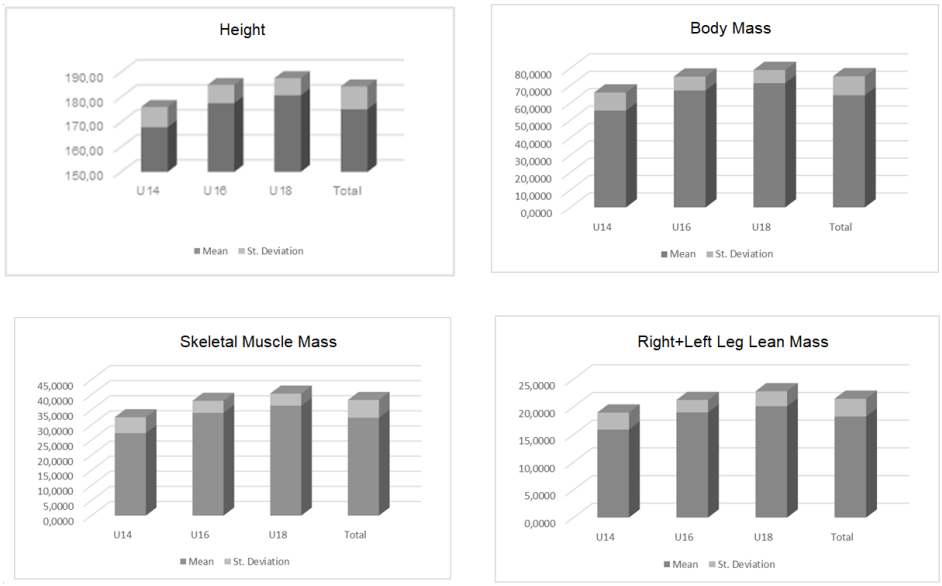

Fig. 1 Body parameters by age group ($p<0.05$)

Analysis of the structure of movements in the agility tests showed that none of the individual movements fully described the characteristics of movements in soccer. Therefore, this study introduced two new complex variables: agility without a ball (AWOB) and agility with a ball (AWB). The AWOB variable was determined by adding up the results a certain player achieved on the *Illinois* test without a ball, *TDS Dribbling Test* without a ball, and *T-Test*. The variable thus obtained is the most characteristic of defensive movements. The AWB variable was calculated by adding up the results a certain player achieved on the *Illinois Test* with a ball drilling on the arbitrary side, the *TDS Dribbling Test* with the dominant leg, and the *TDS Dribbling Test* with the subdominant leg. The variable thus obtained is the most characteristic of offensive movements.

A linear regression analysis was used to examine the relationship between the two variables. Each point in the coordinate system represents a player. Players close to the regression line performed consistently in terms of both AWOB and AWB tests. The points near the origin represent the best performing players. A moderate correlation was found between AWOB and AWB ($r=0.595$; $p<0.000$) (Fig. 2).

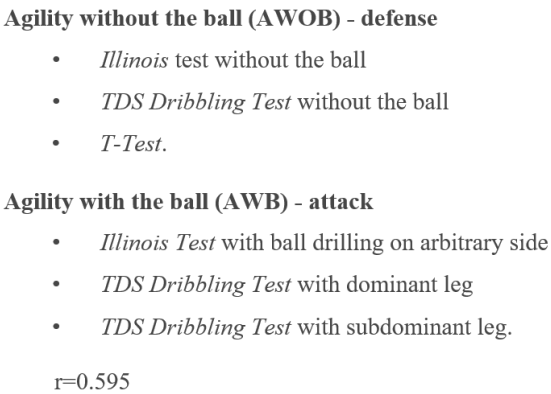

Fig. 2

There was also a moderate correlation between AWB and body composition parameters: SMM, IWM, PM, MM (-0.453, -0.454, -0.453, -0.417). While the following variables show a weaker than average correlation with agility: Height, Mass, BMI, RLLM, LLLM, EWM (-0.318, -0.329, -0.276, -0.332, -0.330, -0.374). There was only a weak correlation between AWB and body type parameters, while no correlation was found between body fat components and agility. The combined agility (hereafter, CAG) index (AWOB+AWB) has a weaker than average correlation with Height, Mass, SMM, BMI, IWM, EWM, PM, MM, R LLM (-0.244, -0.283, -0.365, -0.283, -0.366, -0.344, -0.248), while there is no significant correlation with BFM (Table 2).

Table 2 Correlation between agility indicators and body composition (Pearson)

	Height	Mass	SMM	BFM	BMI
AWOB	-.318**	-.329**	-.453**	.143	-.276*
AWB	-.167	-.217	-.263*	.007	-.245*
CAG	-.244*	-.283*	-.365**	.060	-.283*

	IWM	EWM	PM	MM	R+LLLM
AWOB	-.454**	-.374**	-.453**	-.417**	-.331**
AWB	-.264*	-.216	-.263*	-.253*	-.166
CAG	-.366**	-.301*	-.365**	-.344**	-.248*

Legend: AWOB-agility without the ball; AWB-agility with the ball; CAG-combined agility; SMM-Skeletal Muscle; BFM-Body Fat Mass; BMI-Body Mass Index; IWM-Intracellular Water Mass; EWM-Extracellular Water Mass; PM-Protein Mass; MM-Mineral Mass; RLLM-Right Leg Lean Mass; LLLM-Left Leg Lean Mass; **-Correlation is significant at the 0.01 level (2-tailed); *-Correlation is significant at the 0.05 level (2-tailed).

An examination of the laterality factors (Table 3) revealed that there was a slight difference in the lean muscle mass of the two feet (r=0.998; p<0.000) in the case of the N=56 right-footed soccer players. A weaker than average correlation was found between RLLM and AWOB (r=0.353; p=0.008), while no significant correlation was found with AWB. In the case of right-footed players, a strong moderate relationship is found between AWOB and AWB (r=0.586; p<0.000), and a strong correlation with the CAG (r=0.819; p<0.000). There is an even closer relationship between AWB and the CAG index for right-footed players (r=0.945; p<0.000).

The N=10 left-footed players in the sample showed a slight difference in lean muscle mass of the two feet (r=0.999; p<0.000). No significant relationship was found between the CAG factors and the muscle mass of the two feet. In the case of left-footed players, there is a strong relationship between AWOB and AWB (r=0.730; p=0.017), with a strong CAG index value (r=0.833; p=0.003). There is an even closer relationship between the AWB and CAG index for left-footed players (r=0.986; p<0.000), (Table 3).

Table 3 Laterality

Right Dominant Leg N=56	LLLM	RLLM	AWOB	AWB	CAG
LLLM	1	.998**	-.353**	-.159	-.255
RLLM	.998**	1	-.353**	-.158	-.255
AWOB	-.353**	-.353**	1	.586**	.819**
AWB	-.159	-.158	.586**	1	.945**
CAG	-.255	-.255	.819**	.945**	1

Left Dominant Leg N=10	LLLM	RLLM	AWOB	AWB	CAG
LLLM	1	.999**	.009	-.211	-.168
RLLM	.999**	1	-.011	-.246	-.201
AWOB	.009	-.011	1	.730*	.833**
AWB	-.211	-.246	.730*	1	.986**
CAG	-.168	-.201	.833**	.986**	1

Legend: LLLM-Left Leg Lean Mass; RLLM-Right Leg Lean Mass; AWOB-agility without the ball; AWB-agility with the ball; CAG-combined agility; ** - Correlation is significant at the 0.01 level (2-tailed); * - Correlation is significant at the 0.05 level (2-tailed).

DISCUSSIONS

The study included N=66 young elite soccer players with a span of 6 years in terms of age, and 2-year period for each age group (U14, U16, U18).

Their physique was proportional. The parameters measured by the InBody720 instrument met the standards expected of athletes of their respective ages (see also Szakály, 2008). The high standard deviation observed in each indicator is a good sign of changes in the body composition of young athletes. Their height varied widely, while their SMM and BFM were proportional to body size and meet the standard (Photiou et al., 2008). Obese athletes were not found in the sample. Conscious nutrition and regular, persistent workouts can further improve their body muscle composition through intense development and allow them to be successful athletes in their adult age (Mészáros et al., 2001). Emphasis should be placed on the nutritional composition ensuring the intake of necessary vitamins, minerals, and protein, as other authors have also suggested (Lohman, 1992; Purcell, 2013). In addition to normal nutrition, it is advised to use appropriate isotonic drinks and nutritional supplements, and to provide young people with adequate fluid intake (Németh & Költő, 2014). Instead of empty calories in fast food and soft drinks, regular, high-calorie diets should be preferred, taking into account the correct proportion of each ingredient and the number of calories. To this end, it is encouraged to consult with a nutritionist and inform young athletes and their parents.

In case of the most important physical parameters (SMM, BMI, PM, MM, and RLLM), there was a statistically significant difference between the soccer players of a given age group. The constant growth of these values corresponds to biological development and verifies the work done. No significant difference was found in BFM, which indicated that there are deficiencies in the conscious nutrition of athletes.

Based on this study, it can be concluded that agility is an extremely complex ability, as other authors have a similar view (Bloomfield et al., 1994; Buttifant et al., 2002; Bangsbo & Mohr, 2012), and its connection to other skills and performance components is hard to define (Sheppard & Young, 2006; Koltai et al., 2016), so it is significance for soccer is quite immense (Radák, 2019). The agility tests AWB or AWOB belong to motor tests organically in the case of young soccer players (Momčilović et al., 2020). their relation with other abilities and the performance component structure are quite difficult to define. There are two kinds of agility and we focused on changing directions in our research (Csáki & Takács, 2020).

By examining the correlation between AWOB and AWB, it can be stated that in order to progress, athletes need to practice specific, high intensity exercises which include fast starts, changes of direction, and sudden stops (Lacome, Simpson, Cholley, Lambert, & Buchheit, 2018). Similar conclusions were found in other studies (Condello et al., 2013; Milanović et al., 2014; Koltai et al., 2017). For maximum intensity, AWOB and AWB exercises should be done in combination. The regression graph clearly shows the performance of each player, which can serve as feedback to coaches on how to select players for their positions and how to set up individually differentiated training programs. Similar results were achieved by other researchers (Franks & Hughes, 2016; Sever & Zorba, 2017).

In the examined sample, body parameters showed a moderate to weak connection to AWOB and AWB. The poor relationship between AWB and physical indicators suggests that players still have plenty of room for improvement in ball handling techniques. The lack of correlation between CAG factors and BFM indicates deficiencies in sports specific nutrition.

Examining the laterality factors, it can be concluded that the lean muscle mass of the lower limb of the N=56 (85%) right-footed and N=10 left-footed players is proportional in the sample (Rouissi et al., 2006). However, the difference is not significant.

Specific training must be done to ensure that young footballers can handle the ball effectively with both feet as early as possible. This was included in other methodological descriptions as well (Németh, 2015).

The study verified that body composition of soccer players changes significantly with age. A close relationship between CAG indexes and body composition was not demonstrated. No strong, significant relationship was found between agility indicators and lean muscle mass of the dominant foot of young soccer players.

Modern training methods must be used and abilities which influence agility must be emphasized and consciously planned in order to train a successful soccer player.

This ability is the most important element of all ballgames, the development of which requires different kinds of coaching methods in the case of different age groups. Bompa and Carrera (2015) worked out the long-term periodicity of agility to help soccer players do better. The performed agility tests (measuring the ability changing directions), are based on closed mobility. This type lacks decision processes, so one can plan its achievability. The basis of achievement is doing accelerations and decelerations as fast as it is possible. The best thing is when players use both of their feet in the case of agility with a ball. When acquiring this skill the basis is provided by multilateral coaching.

Particular emphasis should be placed on the proper nutrition of the athletes, thus developing a favorable body composition. The basis of quality nutrition is the balance of macro- and micronutrients. Fiber, vitamin and mineral intake is provided by a balanced diet. When producing ATP one uses high quantities of blood sugar and muscle glycogen. As soon as the physical activity is over, one has to start replacing carbohydrates. The replacement of fluids is also essential. There is evidence that athletes who are hydrated can perform better than dehydrated ones (Kiitam et al., 2018). Cooperation between athletes, parents, coaches and sports dieticians is required to do an efficient nutritional program (Steffl, Kinkorova, Kokstejn, & Petr, 2019).

CONCLUSION

Using the scientific based approach and measurements a complex exercise plan can be made for players and in this way young soccer players can be trained by using tailor-made and post-specified coaching methods. The players who were involved in our research were motivated all the time and they did the tests to help the researchers' work.

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POVEZANOST IZMEĐU AGILNOSTI IGRAČA FUDBALA ADOLESCENATA I NJIHOVE TELESNE KOMPOZICIJE

Cilj ove studije je da se utvrde faktori telesne kompozicije (TK) koji utiču na agilnost fudbalera adolesxenata (N=66), u fudbalskim timovima U14, U16, U18, fudbalskog kluba Topola. Testovi agilnosti (Dribbling test, Illinois test) i instrument Inbody 720 za merenje telesne kompozicije i Oka Starter infracrveni merni instrument za merenje brzine agilnosti korišćeni su u ovoj studiji. Podaci su obrađeni softverom IBM SPSS Statistics 25. Pored deskriptivne statistike, primenjene su i korelaciona matrična analiza, linearna regresija i jednosmerna analiza varijanse (ANOVA) (p<0.05). Utvrđena je umerena korelacija između agilnosti sa loptom i bez lopte (r=0.595), kao i između agilnosti i parametara telesne kompozicije: Mišićna masa skeleta, Unutarćelijska masa vode, Masa proteina, Mineralna masa (r=-0,453, -0,454, -0,453, -0,417, tim redosledom) dok korelacija između agilnosti i Visine, Masa, Indeks telesne mase, Nemasna masa desne noge, Nemasna masa leve noge, Vanćelijska vodena masa, jeste manja od umerene (r=-0,318, -0,329, -0,276, -0,332, -0,330, -0,374, tim redosledom). Utvrđena je blaga korelacija između agilnosti sa loptom i parametara telesne kompozicije. Nije utvrđena korelacija između, agilnosti i mase telesne masti. Uticaj telesne kompozicije na agilnost je manji od očekivanog. Korišćenjem naučno zasnovanog pristupa i merenja može se napraviti složen plan vežbanja za igrače i na taj način može da se sprovede obuka mladih fudbalera prilagođenim i posebno utvrđenim metodama treniranja.

Ključne reči: *agilnost, adolescenti, fudbal, kompozicija tela*.

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Research article

RELATIONSHIP BETWEEN BASIC PERSONALITY DIMENSIONS AND DISPOSITIONAL COPING STRATEGIES IN VOLLEYBALL

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Abstract. *Athletes' coping strategies are important factors that contribute to competitive achievement and psychological well-being. The first aim of the current study was to explore the direct and interactive effects of Five Factor personality dimensions on dispositional coping strategies. The second aim was to test the second-order factorial structure of the Dispositional Coping Inventory for Competitive Sport (DCICS). The sample included 166 female volleyball players of mean age 15.01 years (SD=.87), and mean sports experience of 4.81 years (SD=1.85). They completed the NEO-FFI inventory and DCICS. Explorative factor analyses indicated two second order solutions with high reliability coefficients: task- and emotion-oriented coping strategies. The Paired samples t-test showed that young female athletes more often apply task-oriented strategies than emotion-oriented strategies. The regression analysis showed that some Five-Factor personality dimensions independently predicted the use of higher order coping dimensions. Conscientiousness was the only positive predictor of task-oriented strategies. Neuroticism was positive and agreeableness is a negative predictor of emotion-oriented coping strategies. No interaction effects of personality dimensions on dispositional coping were founded. These findings suggest that the Five-Factor personality model can predict the coping strategies that athletes frequently use. Findings also emphasize the need for more studies aimed to investigate this complex relationship including potential moderator effects of different variables such as gender, sport experience, competitive achievement, and different sports disciplines.*

Key words: *Personality Traits, Coping Strategies, Athletes*

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INTRODUCTION

Sports competitions can be a significant source of stress, and stresses that athletes experience during a competition are often intense (Kimball & Freysinger, 2003). Therefore, it is not surprising that in the last 30 years there is a growing number of studies that focused on stress among athletes. Competitive stress refers to the ongoing transaction between an individual and the demands of the environment related particularly and in direct way to competitive performance (Fletcher, Hanton, & Mellalieu, 2006: 7). There are two different lines in studying competitive stress: within the first, the main interest is the athletes` perception of the sources of the competitive stress (i.e., stressors), and within the second, the authors focused on athletes` cognitions, emotions and coping strategies (Abedalhafiz, Altahayneh, & Al-Haliq, 2010).

Coping strategies are considered to be one of the key processes that can develop self-regulation and involve willing thoughts and activities by which athletes control the physical and psychological demands of the situation (Skinner & Zimmer-Gembeck, 2007). Coping can be assessed at the situation level or the personal, dispositional level (Hurst, Thompson, Visek, Fisher, & Gaudreau, 2011). Within the situational level, coping is defined as the actual or momentary utilization of coping strategies in a particular situation. Within the dispositional approach, individual differences in stable coping strategies are in focus (i.e., dispositions). Dispositions are high predictors of athletes` reactions, and they are stable during long periods of time (Louvet, Gaudreau, Menaut, Genty, & Deneuve 2007).

Whether or not coping strategies are assessed as a process or disposition, there are many types of coping strategies that are classified in different ways: on the micro-analytical and macro-analytical level. The micro-analytical level of classification implies the identification of specific types of coping strategies, for example, seeking social support, imagery, resignation, relaxation (Gaudreau & Blondin, 2004), planning, suppression of competing activities, seeking social support for emotional reasons, humor, denial (Crocker & Graham, 1995). The macro-analytical level of classification implies grouping similar coping strategies into higher-order coping dimensions (Crocker, Tamminen, & Gaudreau, 2015).

Although some authors consider that the classification of specific types of higher-order coping dimensions can mask their diversity and complexity (Compas, Connor-Smith, Saltzman, Harding Thomsen, & Wadsworth, 2001), other authors claim that such classifications are useful because they give a deeper understanding of the usual reactions to competitive stress (Nicholls & Polman, 2007). According to one often referred to classification of coping strategies, strategies are classified into three higher-order dimensions (Nicholls & Polman, 2007): *problem- focused coping strategies* (useful for minimizing distress by reducing and eliminating factors that produce the stress), *emotion-focused coping strategies* (useful for optimising emotional arousal and distress), and *avoidance coping strategies* (behavioural and psychological efforts to avoid stressful situations). Since specific requirements of sport require specific types of coping strategies (Kowalski & Crocker, 2001), some of the classifications are adapted for the context of particular sport. For example, Roth and Cohen (1986) categorized coping as *approach strategies* (the athletes` effort to confront the stressor by taking direct action, planning future activities or putting in more effort) and *avoidance strategies* (the athletes` attempt to avoid a stressful situation). Another classification that is most commonly used in the psychology of sports is the three-factor model (Gaudreau & Blondin, 2004): *task-oriented coping* (strategies for mastering stressful situations, i.e., thought control and imagery),

distraction-oriented coping (strategies for changing the focus to non-sport-related aspects, i.e., distancing oneself from the situation and mental distraction), and *disengagement-oriented coping* (strategies used to abandon a situation and personal goals).

Athletes use various coping strategies (Crocker et al., 2015) and there is evidence of individual differences in responding to competitive stressors and selecting specific coping strategies (Gaudreau & Blondin 2004). Although it can be argued that certain coping strategies are universally efficient, in literature evidence can be found that task-oriented strategies are better predictors of physical and psychological outcomes, and that distraction-oriented and disengagement-oriented strategies are better predictors of poorer physical and mental outcomes and superior achievement (Connor-Smith & Flachsbart, 2007). Understanding the choice of appropriate coping strategies as well as the factors that influence them are crucial for improving the competitive achievement (Nicholls, Taylor, Carroll, & Perry, 2016) and psychological well-being of athletes (Nicholls, Levy, Carson, Thompson, & Perry, 2016).

The basic dimensions of personality can directly affect the process of coping with stress by having influence over choice of strategies for coping with stress (Bolger & Zuckerman, 1995; DeLongis & Holtzman, 2005). In the last couple of decades, a dominant model for assessing basic personality structure is the Five-Factor model (Costa & McRae, 1985). According to this model, the personality can be assessed across five dimensions (Costa & McRae, 1985): neuroticism (N) differentiates emotional adjustment and emotional stability from unadjustment and emotional instability; extroversion (E) relates to proneness to sociability, activism and optimism opposed to introversion – negative emotional states and self-consciousness; openness to experience (O) represents aspiration towards new ideas, experiences and values, as opposed to conservatism and preference of the known over the unknown; agreeableness (A) is an interpersonal dimension that is characterized by love and trust towards people, unselfishness and empathy, as opposed to cynicism, selfishness and distrust; conscientiousness (C) is about control of impulses, setting and achieving goals, being organized, following rules and norms, delaying gratification, being strong minded and self-disciplined as opposed to hedonism, carelessness and laziness.

Unlike other areas of psychology outside of the sports context with a considerable number of investigations of the Five-Five factor on dispositional coping strategies, in the psychology of sport there have only been a few studies dedicated to that matter (Kaiseler, Polman, & Nicholls, 2012; Allen, Greenless, & Jones, 2013; Keiseler, Levy, Nicholls, & Madigan, 2017). One study of the relation between the Five-Factor model on coping was conducted on a large sample of athletes who competed at a variety of sports (Kaiseler et al., 2012). The authors have found that high neuroticism is associated with emotion- and avoidance coping strategies and low neuroticism with problem-focused coping strategies; athletes who scored high on extraversion more frequently used problem-oriented strategies; extraversion and neuroticism are positive predictors of disengagement coping; also, high conscientiousness is a positive predictor of problem-focused strategies, and a negative predictor of emotion-coping strategies. Other research studies have applied a typological approach to exploring possible combinations of personality traits with a sample of athletes who competed in different sport disciplines at different levels of success (Allen et al., 2011). The results showed a greater preference of problem-focused coping strategies is associated with high extraversion, emotional stability, and openness to new experiences. Furthermore, frequent use of emotion-focused coping strategies is associated with high conscientiousness, extraversion, openness, and agreeableness. A greater use of avoidance

coping strategies is connected with lower openness and higher neuroticism. In their recent study, Kaiseler and associates (2017) examined independent and interactive effects of personality traits on dispositional coping in sport. Extraversion, agreeableness, and openness were significant direct predictors of task-oriented strategies. Neuroticism is a positive predictor of distraction-oriented coping, whereas extraversion, agreeableness and conscientiousness are negative ones. Extraversion and neuroticism were positive direct predictors of disengagement-oriented coping strategies, but agreeableness and conscientiousness were negative. In accordance with the results obtained, Allen and associates (2011) reported that there are interactive effects of neuroticism and openness, as well as extraversion and neuroticism in predicting task-oriented coping. Also, the interactive effect of agreeableness and conscientiousness was found in predicting distraction-oriented coping.

Since there is a lack of studies on personality and coping in sport, the main aim of this study was to investigate direct and interactive effects of the Five-Factor factor model on dispositional coping strategies used by young volleyball players. Previous research conducted on a diverse sample included type of sport, age, and competitive level. These studies were not designed to assess this relationship in young athletes who compete in one sport discipline. Practically, it is important to establish the possibility of advising athletes to use coping strategies that are suitable for their personality structure. In addition, the aim of this study was to examine the second order factorial structure of the Serbian version of dispositional coping strategies.

METHOD

Sample

The sample consisted of 166 female volleyball athletes from Belgrade, Niš, Kragujevac and Zrenjanin. The mean age was 15.01 years (*SD*=.87). Mean sport experience was 4.81 years (*SD*=1.85).

Instruments

We used the NEO-FFI inventory (Costa & McRae, 1989) that demonstrates high correlations with analogous scales like the Big Five Questionnaire as to measure up basic personality dimensions (Barbaranelli & Caprara, 2000, in Costa, Oliva, & Cuzzocrea, 2014). This scale contains 60 items grouped into five subscales (12 items per each subscale): Neuroticism, Extraversion, Openness to Experience, Agreeableness, and Conscientiousness. The task of the respondent was to mark the degree to which they found every claim to be truthful. The answers for each item are given on a five-point Likert type scale (from 1=totally inaccurate, up to 5=totally correct). The results are obtained by the sum of answers to all the questions on a corresponding subscale, where a bigger score signifies a greater expression of a given personality trait.

The Dispositional Coping Inventory for Competitive Sport (DCICS) is a theory-based scale for the assessment of coping strategies used by athletes during a competition (Hurst et al., 2011) which represents a modification of the original Coping Inventory for Competitive Sport Instrument (Gaudreau & Blondin, 2002). This scale has 39 items grouped within ten subscales (3 items for the Effort expenditure subscale and 4 items for the other subscales): thought control, mental imagery, relaxation, effort expenditure, logical analysis, seeking support, venting of unpleasant emotion, mental distraction, disengagement/resignation, and social withdrawal. The task of the respondents was to mark the degree to which every item represents their usual thoughts and deeds when faced with competitive stress factors. Answers to every item are indicated on a five-point Likert type scale (from 1=completely disagree, up to 5=completely agree). The results represent an average of answers given on a corresponding subscale, wherein a bigger score signifies a higher frequency of use of a given coping inventory.

Procedure

The research was conducted at sports clubs whose members were female athletes who train volleyball. Prior to the research, the athletes were informed that the research is of a voluntary and anonymous character and that the results will be used for research purposes. The competition of the questionnaire lasted 20 minutes.

Statistical analysis

The data were analyzed with descriptive statistics (*M, SD*). In order to validate the second order factor of the DCICS an explorative factor analysis (Principal component analyses with Oblimin rotation) was performed. The Paired samples t-test was performed to test differences in the frequency of use of task- and emotion-oriented coping strategies. First, a Pearson correlation analysis was applied to test the association between personality dimensions and coping strategies. A hierarchical regression (the enter method) was performed to directly test the interactive effects of Five-Factor personality dimensions on second order dispositional coping strategies. At Step 1 the independent predictor variables were the Five-Factor personality traits (Neuroticism, Extraversion, Openness to Experience, Agreeableness, and Conscientiousness), and the criterion variables were the dimensions of a higher-order factor: task-oriented and emotion-oriented coping strategies. For Step 2, the interaction effects between all Big-Five dimensions were used as predictors and in this step, the predictor variables were mean-centred.

RESULTS

Descriptive statistics

Table 1 presents the descriptive statistics for basic personality traits and strategies for coping with competitive stress. The results indicate that the most prominent traits in athletes are conscientiousness, extraversion and agreeableness. When faced with competitive stress, they most often apply thought control and investing effort and least often resort to resignation and social withdrawal.

Table 1 Descriptive statistics for basic personality traits and stress coping mechanisms

	N	Min	Max	M	SD
Neuroticism	166	17	47	30.96	5.86
Extraversion	166	33	58	44.73	4.23
Openness to Experiences	166	26	52	37.27	4.85
Agreeableness	166	26	52	42.07	4.68
Conscientiousness	166	32	59	48.86	5.04
Thought control	166	2	5	4.17	0.55
Mental imagery	166	1.25	5	3.62	0.75
Relaxation	166	2	5	3.67	0.77
Effort expenditure	166	1.33	5	4.06	0.82
Logical analysis	166	1.5	5	3.87	0.73
Seeking support	166	1	5	3.58	0.79
Venting of unpleasant emotion	166	1	4.75	2.61	0.97
Mental distraction	166	1	4.75	2.26	0.99
Disengagement/resignation	166	1	4	1.65	0.62
Social withdrawal	166	1	4	1.82	0.7

Legend: N=Number of Participants; Min-Minimum; Max-Maximum; M-Mean; SD-Standard Deviation.

Factor analysis

In order to check the second order factor structure of the questionnaire on our sample of respondents, an exploratory factor analysis was conducted on ten subscales. In accordance with previous research (Amiot, Gaudreau, & Blanchard, 2004), a Principal component analysis was applied using an oblimin rotation in two steps. The first step indicated a three-factor solution that was not in line with the theoretical assumptions and was not interpretable. In the second step, two factors were a priori fixed. This solution was in line with theoretically established taxonomies of the coping strategies, as well as with the two-factor solution by the author of the instrument, and it was interpretable. Kaiser-Meyer-Aulkin's measure of adequacy of the sample is .76 which is higher than the recommended value of .60 and Bartlett's test of sphericity is significant (45)=360.74, $p<.01$. These two components explain 50.9% of the total variance, with the first component explaining 31.7%, and the second component explaining 19.2% of the variance. Both components contain subscales with saturations significantly higher than .30. In line with the expectations, the first component, task-oriented coping, contains six different subscales: effort expenditure, logical analysis, relaxation, mental imagery, seeking support and thought control. The second component, emotion-focused coping, contains the following four subscales: disengagement/ resignation, mental distraction, social withdrawal, and venting of unpleasant emotion. Cronbach's alpha coefficients of reliability were good: for the dimension of task-oriented coping (23 items), $\alpha=.87$, and for the dimension of emotion-focused coping (16 items), $\alpha=.84$. A further analysis in this research has been applied in this factor solution.

Table 2 Factor saturations established on the main components with an oblimin rotation method

	Saturations	
	Factor 1	Factor 2
Effort expenditure	.849	
Logical analysis	.835	
Relaxation	.738	
Mental imagery	.733	
Seeking support	.678	
Thought control	.403	
Disengagement/resignation		.797
Mental distraction		.736
Social withdrawal		.625
Venting of unpleasant emotion		.528

Paired samples t-test

A paired samples t-test has shown that there is a significant statistical difference in frequency of use of task-focused coping and emotion-focused coping when facing competitive stressors, $t(132)=25.55$, $p<.00$. Female athletes resort to task-focused coping strategies significantly more often (M=3.56, SD=57).

Correlation analysis

Table 3 shows the correlation (Pearson's) between basic personality traits and stress-coping strategies. Task-focused coping strategies are in a positive correlation with extraversion and conscientiousness, while emotion-focused coping strategies are in a positive correlation with neuroticism and in a negative correlation with agreeableness, conscientiousness and extroversion.

Table 3 Correlations between personality traits and coping strategies

	N	E	O	A	C	TOC	EOC
Neuroticism	1.00						
Extraversion	-.39**	1.00					
Openness to Experiences	-.10	.10	1.00				
Agreeableness	-.29**	.03	.13	1.00			
Conscientiousness	-.38**	.22**	.10	.33**	1.00		
Task-Oriented Coping	-.04	.17*	.01	.04	.40**	1.00	
Emotion-Oriented Coping	.52**	-.21*	-.11	-.45**	-.31**	-.04	1.00

Legend: N-Neuroticism; E-Extraversion; O-Openness to Experiences; A-Agreeableness; C-Conscientiousness; TOC-Task-Oriented Coping; EOC-Emotion-Oriented Coping; *-$p<.05$, **-$p<.05.01$.

Regression analysis

To determine the predictive validity of personality traits for the choice of coping mechanisms, two multiple hierarchical regression analyses were applied (the enter method) in which the criterion variables were task-related coping, or emotion-related coping (Table 4). In the first block, the predictor variables were personality dimensions, and in the second block, the predictor variables were the interaction of each dimension with another (10 in total). Before the interactions were calculated, the data were centred. The results showed a

regression function in which the criterion variable task-focused coping had significant prediction power, R=.45, ΔR^2=.20, F(5, 140)=6.91, p=.00, with the only significant predictor being the conscientiousness dimension. Adding interactions between personality dimensions in the second block did not significantly increase the percentage of the explained variance, ΔR^2=.07, p=.26, total R=.52, ΔR^2=.27, F(15, 130)=3.20, p=.00. The regression function in which the criterion variable is emotion-focused coping also had significant prediction power, R=.63, ΔR^2=.47, F(5, 141)=18.57, p<.05, and the significant predictors were Neuroticism and Agreeableness, which are negatively correlated. Adding interactions between personality dimensions in the second block again did not increase the percentage of the variance explained, ΔR^2=.07, p=.08, total R=.68, ΔR^2=.54, F(15, 131)=7.66, p=.00.

Table 4 Hierarchical multiple regression analysis: prediction of coping strategies based on basic personality dimensions and their interactions

		TOC				EOC		
	ΔR^2	β	t	p	ΔR^2	β	t	p
Block 1	.20				.47			
Neuroticism		.16	1.81	.07		.44	5.79	.00
Extraversion		.12	1.44	.15		.01	0.12	.91
Openness to Experiences		.09	1.12	.27		-.05	-0.74	.46
Agreeableness		-.07	-0.86	.39		-.34	-4.93	.00
Conscientiousness		.44	5.31	.00		-.02	-0.26	.79
Block 2	.07				.07			
Neuroticism		.16	1.65	.1		.45	5.74	.00
Extraversion		.15	1.70	.09		.02	0.25	.80
Openness to Experiences		.09	1.07	.29		-.03	-0.37	.71
Agreeableness		-.1	-1.25	.21		-.37	-5.04	.00
Conscientiousness		.45	5.13	.00		-.06	-0.75	.45
NxE		-.01	-0.09	.93		.12	1.45	.15
NxO		-.01	-0.11	.91		.08	0.88	.38
NxA		-.05	-0.54	.59		.13	1.56	.12
NxC		.09	1.05	.30		-.13	-1.68	.09
ExO		.12	1.15	.25		-.09	-1.01	.31
ExA		-.02	-0.27	.79		.05	0.67	.51
ExC		-.04	-0.38	.71		-.06	-0.75	.45
OxA		-.01	-0.06	.95		-.02	-0.24	.81
OxC		-.18	-2.07	.04		.21	2.42	.02
AxC		.16	1.72	.09		.16	1.96	.05
Total	.27				.54			

Legend: TOC-Task Oriented Coping; EOC-Emotion Oriented Coping; NxE-Neuroticism x Extraversion; NxO-Neuroticism x Openness to Experiences; NxA-Neuroticism x Agreeableness; NxC-Neuroticism x Conscientiousness; ExO-Extraversion x Openness to Experiences; ExA-Extraversion x Agreeableness; ExC-Extraversion x Conscientiousness; OxA-Openness to Experiences x Agreeableness; OxC-Openness to Experiences x Conscientiousness; AxC-Agreeableness x Conscientiousness.

DISCUSSION

Having in mind that athletic competition abounds in stressors, choosing the appropriate coping strategies is important for better competitive achievement as well for the psychological well-being of athletes. The main goal of this research was to investigate the

direct and interactive effects of the Five-Factor model on dispositional coping strategies of young volleyball players. In addition, we wanted to verify the second-order factor structure of the DCICS instrument. According to some theoretical stance, regardless of the fact whether we estimate a process or a disposition, ten subscales of strategies for coping with competitive stress of this instrument can be grouped into second-order dimensions. In their initial work, the authors of the instrument (the version intended to estimate the process) argued that the results of the confirmatory factor analysis did not provide bases for drawing a final conclusion whether a two or three-factor solution is more adequate (Gaudreau & Blondin, 2002). In the same article the authors presented the assumption that the factor structure of the instrument can depend on the characteristics of a sample and it is necessary to have this checked with different samples of participants (including athletes that train different sports disciplines, as well as athletes with different levels of competitive success). In some of the research that followed, a three-factor solution was applied and/or confirmed (Gaudreau, El Ali, & Marivain, 2005; Nichols, Polman, Levy, & Blackhouse, 2008), but in other studies a two-factor solution was used (Amiot et al., 2004; Hajji, Baaziz, Mnedla, Jannet, & Elloumi, 2016). The results of our research have provided a two-factor solution with a high reliability coefficient. The first factor is *task-oriented strategies* (actions for changing or mastering some aspects of a situation), and second, *emotion-oriented strategies* (actions for changing the interpretation of a stressful situation and regulating negative emotions) which integrated items from distraction-oriented coping and disengagement-oriented coping subscales.

Female athletes in our research apply task-oriented strategies significantly more often (activities intended at changing situations during competition), which are considered better predictors of physical mental outcomes and achievement (Connor-Smith & Flachsbart, 2007) than emotions-oriented coping strategies.

In the current study, neuroticism, extraversion, agreeableness, and conscientiousness are in relation with task- or emotions-oriented strategies, but associations between openness and coping strategies were not found. A correlational analysis revealed that extraversion and conscientiousness were associated with using task-oriented coping strategies. Although extraversion is in a positive correlation with task-oriented coping, conscientiousness is only one significant predictor of using task-oriented coping strategies. These results are not in line with previous results in the domain of sport (Allen et al., 2011; Kaiseler et al., 2012). Namely, previous authors reported that extraversion is a positive predictor of task-oriented coping. Practically, athletes in the current research who are high on conscientiousness, i.e., desire to do a task well, tend to be goal-oriented, efficient, and well organized, show self-discipline and rather display planned than spontaneous behaviour, trying to take control over stressful situations, and choose strategies like expenditure, logical analysis, mental imagery, etc. The correlational analysis revealed a tendency for neuroticism to be in a positive and conscientiousness, agreeableness and extraversion in a negative association with use emotion-oriented coping strategies. Regression coefficients showed that neuroticism was positive, and agreeableness was a negative predictor of emotional-oriented coping strategies. That would mean that athletes who are high on neuroticism (emotionally unstable, anxious, hostile, and vulnerable) or low on agreeableness (these who are cynical, rude, and uncooperative) more likely choose coping directed at changing the interpretation of a stressful situation and to managing negative emotions rather than changing the situation. The result that athletes who have tendencies to be less emotionally stable (high on neuroticism) is in line with previous research (Allen et al., 2011; Kaiseler et al., 2012; Kaiseler et al., 2017) that athletes who are

high on neuroticism tend to use more distraction- and disengagement-oriented coping (the scales that were integrated in our research). The result obtained in this research, that agreeableness is a negative predictor of emotional-oriented strategies, is not in compliance with previous studies in the context of sport (Kaiseler et al., 2012; Kaiseler et al., 2017) that showed that this dimension independently or in interaction with other personality dimension is a predictor of task-oriented coping.

A possible explanation for somewhat different results obtained in this study compared to the results of previous research would be that in the previous research the samples were heterogeneous considering the type of sport (including different individual and team sports), age, sport experience and competitive achievements. In the present study the sample consisted of young volleyball players. Volleyball is a sport that requires a high level of player cooperation and a uniqueness of volleyball is manifested in the rules of winning points. According to the rules, when a player misses or does not score a point (that is not the case in other team sports), the point goes to the opponent. Any change in points may be potentially stressful. Thus, for example, athletes who are low on agreeableness, and who are less trustful, cooperative, and compliant tend to use more actions that are implemented to reframing a stressful situation and to regulating negative emotions.

Because of the general lack of research findings exploring the interaction effects of the Five-Factor personality traits on dispositional coping in the context of sport, it is not possible to formulate any firm empirically based hypotheses as to why no interactive effects were found in the present study.

CONCLUSION

This study is the second one in the context of sport and it is aimed at exploring the relationship between the Five-Factor personality dimensions and coping at the dispositional level. Such findings confirm the assumption that there are connections between basic personality dimensions and dispositional coping in the context of sport competition. The second aim of this study was to examine the second order factorial structure of the Serbian version of dispositional coping strategies. The obtained results indicated that it is valid to assess two high order factor structures: task-oriented coping and emotion-oriented coping in the volleyball.

Potentially, such results can have a practical value and can encourage coaches and applied sport psychologists to urge those athletes who are high on neuroticism and/or low on agreeableness to more frequently choose task-oriented coping strategies and to prevent them from using coping strategies that are not in accordance with their personality dimensions.

The findings of this study have some limitations that give directions for future research. The main limitation of this study refers to the sample size, which is relatively small and not sufficient for application of a confirmatory factor analysis. Future research could explore these relationships including the potentially moderating effect of social-demographic variables, i.e., gender differences, different sport experience, competitive achievement, and differences between team sports. From a practical point, it would be valuable to examine the effect of the intentions to train and encourage athletes, especially those with high neurotic or low agreeableness, to use more task-oriented coping strategies.

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ODNOS IZMEĐU OSNOVNIH DIMENZIJA LIČNOSTI I DISPOZICIONIH STRATEGIJA SUOČAVANJA SA STRESOM U ODBOJCI

Strategije suočavanja sa stresom koje koriste sportisti smatraju se značajanim faktorom koji doprinosi takmičarskom postignuću, kao i psihološkoj dobrobiti sportista. Ciljevi ovog rada bili su da se ispitaju direktni uticaji i efekti interakcije Big Five dimenzija ličnosti na dispozicione dimenzije suočavanja sa stresom drugog reda i da se testira faktorotska struktura drugog reda Inventara dispozicionih strategija suočavanja sa stresom. Uzorak je činilo 166 odbojkašica prosečnog uzrasta 15.01 godina (SD=.87)i prosečnog sportskog staža 4.81 godina (SD=1.85). Ispitanice su popunile NEO-FFI inventar i inventar za procenu dispozicionih strategija suočavanja sa takmičarskim stresom-DCICS. Eksploravnom faktorskom analizom je dobijeno dvofaktorsko rešenje drugog reda sa visokim koeficijentima pouzdanosti: suočavanje usmereno na zadatak i suočavanje usmereno na emocije. Regresiona analiza je pokazala da su neke od BigFive dimenzija ličnosti nezavisni prediktori stategija suočavanja višeg reda. Savesnost je pozitivan prediktor strategija usmerenih na zadatak. Neuroticizam je pozitivan, a saradljivost negativan prediktor strategija suočavanja usmerenog na emocije. Nijedna od interakcija BigFive dimezija ličnosti nije značajan prediktor dispozicionih dimenzija. Dobijeni nalazi ukazuju na to da petofaktorski model ličnosti može da bude od koristi u identifikovanju stretegija suočavanja koje sportsiti primenjuju. Takođe, nalazi ističu potrebu ka dodatnim istraživanjima namenjenim ispitivanju ovog složenog odnosa uključujući i moguće delovanje moderatosrskih varijabli kao što su pol, takmičarsko iskustvo i različite sporske discipline.

Ključne reči: *crte ličnosti, strageije suočavanja, sportisti*

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Narrative review article

MUSCLE ACTIVATION DURING FOREHAND AND BACKHAND DRIVES IN THE SPORT DISCIPLINE OF TENNIS

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Abstract. *Tennis is one of the most popular individual sports all over the world. Strength and trained muscles are required for a player in order to achieve a good backhand, forehand, volley or flat stroke. Especially while playing tennis are many kinds of muscles involved, including the lower body muscles, trunk muscles and upper body muscles. The purpose of this review is to present the activated muscles in the basic tennis movements of forehand and backhand and to improve the knowledge about their role in order to help tennis players and coaches to enhance their tennis performance and to reduce risk of injury. To support the present review, data were gathered from library and network databases using keywords such as tennis, muscles, forehand, and backhand for publications between 2015 and 2019. Overall, thirty-five references were detected and used. The literature showed that forehand and backhand drives are strokes that involve muscles not only of the upper limbs but also a series of more complex movements that start with the feet and end with the swinging of the tennis racket. The insight for the action of the muscles in tennis should be utilized in tennis players so as to better understand the muscular function which takes part in specific tennis movements and has a greater performance. In addition, this knowledge is considered strongly beneficial for the coaches and the favourable building of the training process.*

Key words: *Tennis, Muscle, Tennis Stroke, Forehand, Backhand*

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INTRODUCTION

The human muscular system is made up of striated or skeletal muscles. The study of muscles in general, especially in terms of energy, is very interesting and essential for understanding the motor functions of the human body. The alternating energy of the muscles on the bones and joints achieves the harmonious kinetic functions of body parts, which are unlimited, e.g. the upright posture, the gait, the upper limb conceiving abilities, the hormonal motions of the torso to maintain balance, etc. (Capitano, Moriggi, & Gelfi, 2017; Tohanean, 2018; Lai, Biewener, & Wakeling, 2019; Alexe, Alexe, Tohanean, & Tudose, 2020).

This review addresses the activated muscles during the basic strokes of forehand and backhand drives in the very popular racquet sport discipline of tennis. It is noteworthy that during the action of a muscle not all muscle fibers are contracted, but only certain motor units, depending on the mechanical work performed. The bigger the project, the more motor units operate. Muscle force is exerted on the adhesive points of the muscle.

Almost all the body muscles are involved in tennis. Many of the muscle actions regarding the lower body are just the same for all the tennis strokes (Ivančević, Jovanović, Đukić, Marković, & Đukić, 2008; Elce et al., 2017; Roeter & Kovacs, 2019). At the same time, they workout evenly and develop rapidly in racing tennis. They derive their energy from the breakdown of ATP (adenosine triphosphate), which is the direct source of energy. However, ATP is not always enough for the energy which is in need. Thus, ATP is reconstituted from indirect sources of muscle energy, such as CP (phosphocreatine - three times the amount of ATP), glycogen and fats (Rodrigues, & Del Valle, 2018; Sawali, 2018). The first case applies to relaxed movements in rest and preparation while the second occurs in intense and fast movements. The muscles in tennis act isotonic and isometric. The isometric contraction is mainly about the racket handle as well as the bent legs at standby. It is essential for the muscles which act isometric to be extremely well-trained, because a strong and good stroke depends on a firm grip and strong legs (quadriceps, thighs) (Zhang et al., 2016; Colomar, Baiget, & Corbi, 2020)

The purpose of this review is to present the activated muscles in the basic tennis movements of forehand and backhand and to improve the knowledge about their role in order to help tennis players and coaches enhance their tennis performance and reduce risk of injury.

METHODS

In order to elaborate this review, we have identified numerous updated bibliographic sources that have focused on scientific aspects regarding the way in which the muscles of the human body are involved in performing the usual movements, but also of some procedures specific to the game of tennis. Bibliographic sources aimed at the field of human anatomy and physiology, physiotherapy, kinesiology, but also studies that refer to interdisciplinary fields were accessed. Among the latter, of interest are those with a predilection focused on performance training in tennis. In this regard, various international databases were accessed (Web of Science, Scopus, Springer Link, DOAJ and Google Scholar). We have given specific attention to the bibliographic sources from the last five years, with the idea of highlighting new aspects of the topic we researched.

THEORETICAL CONSIDERATIONS OF THE PROBLEM

Tennis movements and muscular activation

A. Grip

The following analysis applies to any grip used: Eastern, Continental, Semi-continental. To tighten the fingers and palm on the racket the activation of the following is necessary: flexor digitorum superficialis, palmaris longus, flexor carpi ulnaris, flexor pollicis longus and flexor digitorum profundus (Burute & Vatsalaswamy, 2017; Hodde, Ioannou, & Altenmuller, 2019).

They are anterior and posterior muscles of the forearm, which flex the fingers and the wrist. The flexor carpi radialis is responsible for the angle formed between the racket and the forearm. The opening of the toes to change the grip is made by the muscles of the dorsal side of the forearm - the extensor surface – which include: the extensor carpi radialis longus, extensor carpi radialis brevis, extensor digitorum communis muscle, extensor digiti minimi proprius, extensor carpi ulnaris, extensor pollicis brevis (West, Ricketts, & Brassett, 2017; Save & Fishman, 2019).

The pronator quadratus with the pronator teres takes part in the change from the Eastern to the Continental grip.

B. Standby position

The preparation of each player for a stroke starts from the standby position, also called the basic position. For the two basic strokes, the forehand and backhand, the standby position is the same.

The player stands with his feet as wide as the shoulders. The knees are slightly bent and the body weight is evenly distributed on the legs and even more on the tiptoes, the body has a slight inclination forward. The racket is held with both hands in front of the body with bent elbows close to the body. The hold is made in such a way that the head of the racket is higher than the grip. Therefore, in this position all the muscles in the body are in increased muscle tone. However, it does not seem to produce and generate traffic. This is because the muscles work isometrically.

C. Basic strokes

C.1. Forehand Drive

The term forehand is used as a base for all the strokes from the right position for the right-handed and the opposite for the left-handed (Agrotou, 2015).

a) Preparation phase

In the preparation phase, in order to lift the hand holding the racket to the horizontal position, the lateral deltoid is contracted with the posterior deltoid leading to the abduction and outward turn of the arm. Also, the teres minor and teres major muscles are involved. For the flexion of the elbow, the anterior arm is contracted by working with the biceps brachii. Turning the torso to the right is achieved after the right obliquus internus abdominis muscle and the left obliquus extremus abdominis muscle. The transversospinal muscular system also helps. The right sternocleidomastoid muscle is involved in preventing the head from turning when the torso turns right.

The slight inclination of the torso is helped by the abdominal muscles. The walking muscles such as the iliopsoas, sartorius and pectineus muscle are activated during the

preparation steps. Ancillary muscles are the adductor magnus (upper bundles), the adductor minimus, the adductor longus and the tensor fascia lata muscle (Genevois, Creveaux, Hautier, & Rogowski, 2015). The main muscles for the extension of the tibia are the quadriceps, which comprises the rectus femoris, the vastus lateralis, the vastus medialis and the vastus intermedius. The activated muscles for the dorsal flexion of the footing are the tibialis anterior, the anterior perineum and the extensor digitorum longus. The ancillary muscle is the extensor hallucis. The main muscles for flexion of the tibia are the biceps femoris, the semimembranosus and the semitendinosus. Ancillary muscles are the sartorius muscle, the gracilis, the popliteus muscle, the gastrocnemius and the soleus muscle. In addition, for the left foot to move right and in front of the above walking muscles, the adductor muscles (the adductor magnus, the adductor minimus, the adductor longus and the gracilis) also participate (Zdilla, Paulet, Lear, Addie, & Lambert, 2018; Olewnik, Podgorski, M., Polguj, M. Ruzik, K., & Topol, 2019; Bordoni & Varacallo, 2020).

b) Hitting phase

To move the right hand (with the racket) forward where it will hit the ball, the pectoralis major is contracted, working with the anterior deltoid. Also, in order to stretch the hand, the triceps with the elbow muscle is contracted. To restore the torso forward, the left obliquus internus abdominis muscle works with the right obliquus extremus abdominis muscle. For stretching the legs, the quadriceps act mainly, and for the lifting of the heel from the ground (where the next step will be followed) the muscles of the plantar flexion are involved. The main muscles are the gastrocnemius and the tibialis posterior.

The auxiliary muscles are the soleus, the peroneus longus, the peroneus brevi, and the tibialis posterior. The left hand makes a slight bend in the elbow where the biceps brachii and anterior arm contract and is usually abandoned in inertia forces (Jarmey & Sharkey, 2015; Whiting, 2019).

c) Final phase

With the start of the preparatory phase, the hand remains almost stretched and then bends. Its direction is from the bottom to front and up and left. This movement of the right hand involves the anterior portion of the deltoid muscle along with the pectoralis major muscle, which pulls the arm inward. Additionally, the shoulder blade is directed forward, the muscles that contribute to this movement are the rhomboid and the serratus anterior muscle. The right foot is ready to leave the ground and take a new step, with the gastrocnemius and the tibialis posticusmuscle working together (Maharaj, Cresswell, & Lichtwark, 2016; Martin, Bideau, Delamarche, & Kulpa, 2016; Larionov, Yotovski, & Filgueira, 2018).

C.2. Backhand Drive

The standby position is the same as for the forehand drive.

a) Preparation phase

At the beginning of the preparation phase, the wrist (with the racket) is bent and the whole hand is driven to the left. The left hand also helps in this movement. This bending is mainly due to the contraction of the flexor digitorum superficialis; also, the auxiliary muscles carry most of the flexor digitorum (Roeter & Kovacs, 2019).

With the energy of the anterior portion of the deltoid and pectoralis major muscle, the right arm slightly rises and moves to the left. For the flexion of the forearm towards the

arm, the anterior arm with the biceps brachii cooperates contracted. The flexors muscles of the fingers of the left hand are activated to hold the racket from the neck , which act isometrically and are mentioned on the previous page. To pull the same hand backwards and inwards, the teres major, the infraspinatus and the posterior deltoid are contracted. The torso and hips point to the left from the left obliquus internus abdominis muscle, the right obliquus extremus abdominis muscle, and the transversospinal system. Contracting the right rectus abdominis with the obliquus internus abdominis muscle the obliquus extremus abdominis muscles lean the torso forward and right (Genevois, Reid, M., Rogowski, I., & Crespo, 2015; Kumar & Kumar, 2017).

In order for the left foot to move left and forwards and then to follow the right foot to the left and front, the walking muscles (flexors of the tibia, thigh, soleus and extensor muscles attached to them, as well as the adductors with the abductors muscles) must cooperate and contract at the same time, reported in detail in the steps of the forehand drive (Fields & Rigby, 2016).

b) Hitting phase

The hand holding the racket is guided downwards and forwards where the racket will strike the ball at the extension of the right foot and at approximately the height of the knee. Therefore, in order to move the right arm forward (anatomically backwards) and below, the posterior deltoid, the supraspinatus and the teres major are involved. The triceps, working with the elbow muscle, extend the forearm just before hitting. As for the shoulder blade, it is raised up and back with the contraction of the rhomboid muscle and the levator scapulae. Also, the torso extends backward with the energy mainly of the two latissimus dorsi muscles and spinal extensor muscles. The legs are stretched with the contraction of the quadriceps, the gastrocnemius and the tibialis posterior muscle (Bolsterlee, D'Souza, Gandevia, & Herbert, 2017; Özek, 2020).

c) Final phase

The right hand begins to move away from the torso, continuing the movement until the arm reaches approximately a horizontal position. In this movement the deltoid and especially the lateral, the coracobrachial, supraspinatus, in cooperation with the upper trapezoid slightly elevate the shoulder blade. At this stage, the player rests on his toes and is ready for the move. The weight of the body lies mainly on the right foot. The gastrocnemius, the tibialis posterior, the peroneus longus, brevis, and the tibialis posterior act all in this (Bisschops & Lavallee, 2016; Saeki et al., 2018).

To restore the torso and hips from the turn that it had already made in the preparatory phase, the right obliquus internus abdominis muscle and left obliquus extremus abdominis muscle take part, even the transversospinal system that includes the semispinalis muscle, the multifidus muscle and the rotators. In order to keep the head-face fixed in a position that sees the coming ball and not to be dragged by the corners of the torso, the sternocleidomastoid and the semispinal act primarily (Sanchis-Moysi et al., 2016; Myers & Kibler, 2018; Amaro, Paulino, Neto, & Roseiro, 2019).

Finally, it is noteworthy to report that the descriptions of the techniques are about the right-handed, the exact opposite is valid for the left-handed. The activated muscles in the aforementioned basic tennis movements are presented in Table 1.

Table 1 Muscles action in basic hits in tennis.

	Movements – Stroke techniques	*Muscles in action*
	Grip	flexor digitorum superficialis, palmaris longus, flexor carpi ulnaris, flexor pollicis longus and flexor digitorum profundus, extensor carpi radialis longus, extensor carpi radialis brevis, extensor digitorum communis muscle, extensor digiti minimi proprius, extensor carpi ulnaris, extensor pollicis brevis, pronator quadratus, pronator teres
	Standby position	All body muscles work isometrically and in increased muscle tone
Forehand Drive	Preparation Phase	lateral deltoid, posterior deltoid, teres minor and teres major, biceps brachii, obliquus internus and extremus abdominis, sternocleidomastoid, iliopsoas, sartorius, pectineus, adductor magnus (upper bundles), adductor minimus, adductor longus, gracilis, tensor fascia lata, rectus femoris, vastus lateralis, vastus medialis, vastus intermedius, tibialis anterior, anterior perineum, extensor digitorum longus, extensor hallucis, biceps femoris, semimembranosus, semitendinosus
	Hitting Phase	pectoralis major, anterior deltoid, triceps, elbow, left obliquus internus abdominis, right obliquus extremus abdominis, quadriceps, plantar flexion, gastrocnemius, tibialis posterior, soleus, peroneus longus, the peroneus brevi, tibialis posterior, biceps brachii,
	Final Phase	deltoid, pectoralis major, rhomboid, serratus anterior, gastrocnemius, tibialis posticus muscle
Backhand Drive	Preparation Phase	flexor digitorum superficialis, deltoid, pectoralis major muscle, biceps brachii, flexors muscles of the fingers, teres major, the infraspinatus and the posterior deltoid, right rectus abdominis with the obliquus internus abdominis muscle and the obliquus extremus abdominis muscles, right rectus abdominis, obliquus internus abdominis, obliquus extremus abdominis, flexors of tibia, thigh, soleus, adductors, abductors
	Hitting Phase	posterior deltoid, the supraspinatus, teres major, triceps, elbow, the rhomboid, levator scapulae, latissimus dorsi, spinal extensor, quadriceps, gastrocnemius, tibialis posterior
	Final Phase	deltoid, lateral, coracobrachial, supraspinatus, upper trapezoid, gastrocnemius, tibialis posterior, peroneus longus, brevis, tibialis posterior, obliquus internus abdominis, left obliquus extremus abdominis muscle, semispinalis, multifidus, rotators, sternocleidomastoid, semispinal

CONCLUSIONS

Tennis is a sport that involves muscles not only of the arms and wrists but also a series of complex movements which begin from the feet and end in a racket swing as the final move. It requires a well-trained and honed set of muscles to execute movement with the speed needed as well as the power that is demanded regardless of the player's tennis level. That is because each player uses the same group of muscles in all of them. The feet movements used for jumping and running are the initial links, which are followed by hips, legs, trunk, arms and the hand at last. Initially, muscles of the lower body are the first group involved when playing tennis. Following up are the upper legs, which include the quads and the hamstrings. The energy and power are transferred to the gluteus maximus and medius. The group of trunk muscles are next in the continuous kinetic action. Finally, regarding the upper body it includes the major muscles, and the upper back mainly sets in motion the rhomboid and trapezius, which continue to the upper arms. The last muscles that also take part are the flexor and extensor of the antibrachium.

The insight for the action of the muscles in tennis should be effectively utilized in tennis players in order to enhance their physical performance. Moreover, this knowledge is considered strongly helpful for the coaches and the favourable building of the training process as well as for the sports doctors and physiotherapists coping with injuries in tennis players.

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AKTIVACIJA MIŠIĆA TOKOM FORHEND I BEKEND UDARACA U TENISU

Tenis je jedan od najpopularnijih individualnih sportova širom sveta. Snaga i utreniranost mišića su neophodni igraču kako bi postigao dobar bekhend, forhend, volej ili ravni udarac. Tokom igranja tenisa uključene su brojne vrste mišića kao što su mišići donjeg dela tela, mišići trupa i mišići gornjeg dela tela. Cilj ovog preglednog rada je da predstavi mišiće aktivirane u osnovnim teniskim pokretima forhenda i bekhenda i da poboljša znanje o njihovoj ulozi kako bi se teniserima i trenerima pomoglo da poboljšaju svoje sportske učinke i smanje rizik od povreda. U cilju pregleda literature, podaci su prikupljeni iz baza podataka biblioteka i sa interneta koristeći ključne reči kao što su tenis, mišići, forhend, bekhend i u publikacijama između 2015. i 2019. godine. Ukupno je pronađeno i korišćeno trideset pet referenci. Literatura je pokazala da su forhend i backhand udarci koji uključuju mišiće ne samo gornjih ekstremiteta već i niz složenih pokreta koji počinju u stopalima, a završavaju se zamahivanjem teniskog reketa. Uvid u delovanje mišića u tenisu treba koristiti kod tenisera kako bi se bolje razumele mišićne funkcije koje učestvuju u određenim teniskim pokretima i koje su važne za ostvarivanje boljeg sportskog učinka. Pored toga, ovo znanje se smatra izuzetno korisnim za trenere i povoljnim za izgradnju trenažnog procesa.

Ključne reči: *tenis, mišići, teniski udarac, forhend, bekend*

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Research article

SELF-PERCEPTION OF SPORTING ABILITIES OF FEMALE ATHLETES WHEN COMPARED WITH SAME-SEX AND OPPOSITE-SEX ATHLETES

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Abstract. *The aim of this study is to determine how top-level female soccer and volleyball players, and young, cadet and junior female volleyball players view themselves, their abilities, and their specific motor skills for sport in relation to other female and male athletes. In Study 1, the sample consisted of 24 female top soccer and volleyball players of the highest sporting rank in Serbia. In Study 2, the sample consisted of 31 female cadet and junior volleyball players. They all filled out a brief questionnaire regarding self-perception about their sporting abilities, when compared with same-sex and opposite-sex athletes of the same rank, sport and age. The results of Study 1 show that female top soccer and volleyball players perceive themselves as less competent when compared with male athletes of the same sport and age ($t(22)=5.97$, $p=.00$). The results of Study 2 show that female cadet and junior volleyball players perceive themselves as less competent in Serve strength ($t(29)=3.27$, $p=.030$) and Physical endurance and strength ($t(29)=2.52$, $p=.017$) when compared with male volleyball players of the same age. The obtained results call for further examination of gender differences in perceived self-competence.*

Key words: *Female Athletes, Self-Perception, Competence, Soccer, Volleyball*

INTRODUCTION

The sense of competence has represented a significant construct within the psychology of sport over the years. The beginnings of research into athlete behavior as well as athletic achievement are tied precisely to the athlete's experience of being competent. Starting with Susan Harter's self-esteem theory (Harter, 1987), followed by

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attribution theory (Weiner, 1985), achievement goal theory (Nicholls, 1989), and self-determination theory (Deci & Ryan, 2012), competence is the significant construct associated with many behavioral, affective, and cognitive sport outcomes, and as such plays an important role in the life of the athlete.

According to these theories, the need for competence is innate and each individual strives to feel competent in different domains of life. The sense of competence directly influences an athlete's behavior. An athlete with a sense of competence will strive for a goal, a situation of achievement, while an athlete with a sense of incompetence will strive to avoid situations where he or she may fail and be perceived as incompetent. The sense of competence refers to the athlete's belief that he or she possesses the necessary skills and abilities to overcome challenges and tasks. Perceived competence in fact plays a more crucial role in an individual's activity than concrete indicators of competence (Bandura, 1977).

Bandura considers similar constructs, where the perception of self and self-performance can also be viewed as self-efficacy. According to Bandura's theory of self-efficacy (1977), it is based on the personal belief and expectation that a person can master or perform a task. In a match-like situation, a high level of self-efficacy contributes to better achievement on the field and a lower level of emotional arousal. The sense of competence and efficacy are directly linked to achievement of the goal (Bandura, 1977). More specifically, a belief in one's own efficacy is a fundamental factor in setting and achieving goals, as well as the choice of activities to be pursued by the person, and whether he or she will continue the activity (Eccles & Wigfield, 2002). According to Bandura (1977), the evolvement of self-efficacy is affected by personal experience, the experience of others, significant others, and the psychophysiological state of pleasantness. In addition to a personal experience of competence, for the development of self-efficacy, feedback from significant others represents a significant factor. Bandura's theory, as well as other social-cognitive theories, stress the importance of social factors, or the environment, in the development of an individual's internal processes. In addition to assessing performance, the way others value a certain situation also shapes athletes' beliefs about themselves as well as the activity in which they are participating.

In the past, sport was the dominant masculine category of physical activity; women slowly entered the sports scene in late nineteenth and early twentieth centuries, first only those belonging to higher circles of socioeconomic status, and later, in the twentieth century, within competitive categories (Đorđić et al., 2013). When comparing the number of female athletes (1.8% of the total number of participants) at the 1908 Olympic Games in London and the last Olympic Games in Rio de Janeiro (45%), there is a trend of increase in the number of women competing in sports at the national and international level. However, despite a greater number of women competing in sports, there are still gender differences in both the level of participation in sports and the perception of women about their personal performance in sports.

Although there are clear biological differences between genders, which affect the very differences in male and female sports, socio-cultural differences and gender stereotypes equally affect different understanding and treatment of male and female athletes (Chalabaev, Sarrazin, Fontayne, Boiché, & Clément-Guillotin, 2012). If we consider that there is a difference in the socialization of boys and girls from birth, it is not surprising that these differences have been transmitted to the domain of sport. Thus, boys focus on sports to develop motor skills, physical strength, and achieve considerable sporting success (Chalabaev et al., 2012), while girls focus on sports to develop good posture and body appearance.

The different socialization of men and women, as well as the stereotypical understanding of men and women's sports, have proven to be significant in the formation of athletes' self-confidence and competence. Research has shown that women and girls find that they are less athletically competent than men and boys (Kalaja, Jaakkola, Watt, Liukkonen, & Ommundsen, 2009; O'Connor, Gardner, Larkin, Pope, & Williams, 2020). The beliefs they have about themselves and their abilities greatly influence the decision to continue participating in sports, as well as the decision to play sports professionally.

With the notion that women should not have a strong body, and that it is not socially desirable to be overly aggressive and penetrating, women in sports face many stereotypes and prejudices that make sport experts view women's sports differently than men's.

As sports self-esteem has a considerable impact on athletic achievement alone (Moritz et al., 2000), it seems the relevant research problem within women's sports due to the decreasing number of girls taking active part in sports, as well as the increasing percentage of girls dropping out of sports (Guillet, Sarrazin, Carpenter, Trouilloud, & Cury, 2002; Enoksen, 2011).

Hence, previous studies pointed out gender differences in sports, and how they affect the development of the athlete themselves.

The aim of this study is to determine how top-level female soccer and volleyball players, and young, cadet and junior female volleyball players view themselves, their abilities, and their specific motor skills for sport in relation to other female and male athletes.

METHOD

The current study is divided into Study 1 and Study 2.

Study 1

The sample consisted of 24 female athletes playing soccer (N=13) and volleyball (N=11) in the Super League of Serbia (the highest level of sport competition in Serbia), aged 14 to 27, who have been actively involved in soccer and volleyball for 9.95 years on average. The athletes completed a sociodemographic questionnaire on the premises of the club in the presence of psychologists, which included two questions regarding self-assessment of athletic ability.

The first question (Q1) pertained to self-assessment of athletic ability in relation to other female athletes of the same age and competitive rank ("What grade would you give yourself as a player in relation to female athletes of your age involved in this sport?"). The second question (Q2) addressed self-assessment of athletic ability in relation to male athletes of the same age and competitive rank ("What grade would you give yourself as a player relative to male athletes of your age involved in this sport?"). The score ranged from 1 to 5, with five representing the highest score.

Study 2

In order to further investigate the differences in perceptions of female athletes (in specific volleyball elements) competing within the cadet and junior categories, an additional study was conducted.

The sample consisted of 31 female athletes playing volleyball, aged 12-17, who were attending a volleyball camp at the time of data collection. The athletes have been actively involved in volleyball for 4.5 years on average.

On this occasion, the respondents evaluated their own performance in specific volleyball elements in relation to other female volleyball players and in relation to other male volleyball players of the same age, on a three-step scale. The specific volleyball elements within which they evaluated their performance at all the positions (how good they were at performing a particular element) were: the spike, block, receive, serve, setting, spike strength, serve strength, defense game, offense game, reaction speed, quality of relations with the teammates, quality of the relationship with coach, physical endurance and strength.

RESULTS

Study 1

Based on Table 1, it can be observed that female athletes have higher scores when evaluating themselves compared to female athletes (Mean=3.58), than when they compared themselves to male athletes of the same rank and sport. To test for statistically significant differences in these two estimates, a t-test analysis for paired samples was performed.

Table 1 Athlete's self-assessment scores

	N	Minimum	Maximum	Mean	SD
Compared to other female athletes (Q1)	24	3	5	3.58	.65
Compared to male athletes (Q2)	23	1	4	2.60	.72

Legend: Q1-Question 1; Q2-Question 2; SD-Standard Deviation.

The results of the t-test for paired-samples (Table 2) indicate that there is a statistically significant difference in the assessment of athletic ability when female athletes evaluate their performance compared to other female athletes and male athletes.

Table 2 Results of the t-test for paired-samples

	Mean	SD	df	t	p
Q1-Q2	.95	.76	22	5.97	**.00**

Legend: Q1-Question 1; Q2-Question 2; SD-Standard Deviation; p-significance set at level p<.05.

A t-test analysis for independent samples was conducted to further examine whether there were statistically significant differences in the self-evaluation of female athletes regarding the type of sport they were engaged in.

Table 3 Results of the t-test for independent samples

	Sporting group	Mean	SD	df	t	p
Self-evaluation of athletic ability in relation to female athletes	FCP	3.76	.72	22	1.56	.133
	FVP	3.36	.50			
Self-evaluation of athletic ability in relation to male athletes	FCP	2.75	.62	21	.979	.339
	FVP	2.45	.82			

Legend: FCP- Female Soccer Players; FVP- Female Volleyball Players; SD-Standard Deviation; p-significance set at level p<.05.

The results show that there is no statistically significant difference in the self-evaluation of the athletic ability of female soccer players and female volleyball players (Table 3).

Study 2

In order to further examine the differences in the athletes' perceptions of personal athletic ability (specific sport skills) in relation to female volleyball players and male volleyball players, within Study 2, a t-test for paired samples was conducted, where the variables were scores on specific volleyball elements relative to female and male volleyball players.

Table 4 Results of t-test for paired samples for specific volleyball elements

	Scores	Mean	SD	df	t	p
Spike	Compared to FP	2.03	.66	29	1.00	.26
	Compared to MP	1.90	.70			
Block	Compared to FP	1.76	.72	29	-.254	.801
	Compared to MP	1.77	.80			
Receive	Compared to FP	2.26	.69	29	.00	1.00
	Compared to MP	2.25	.68			
Serve	Compared to FP	2.43	.57	29	1.07	.293
	Compared to MP	2.29	.69			
Setting	Compared to FP	1.89	.72	28	-.571	.573
	Compared to MP	1.96	.87			
Spike strength	Compared to FP	2.10	.66	29	1.88	.070
	Compared to MP	1.90	.70			
Serve strength	Compared to FP	2.30	.70	29	3.27	**.030**
	Compared to MP	1.96	.83			
Defense game	Compared to FP	2.33	.70	29	.701	.489
	Compared to MP	2.25	.63			
Offense game	Compared to FP	2.20	.71	29	.571	.573
	Compared to MP	2.12	.71			
Reaction speed	Compared to FP	2.48	.63	28	.372	.712
	Compared to MP	2.45	.67			
Quality of relationship with teammates	Compared to FP	2.58	.73	28	-1.14	.264
	Compared to MP	2.64	.55			
Quality of relationship with coach	Compared to FP	2.26	.69	29	-.902	.375
	Compared to MP	2.32	.79			
Physical endurance and strength	Compared to FP	2.56	.56	29	2.52	**.017**
	Compared to MP	2.25	.68			

Legend: FP-Female Players; MP-Male Players; SD-Standard Deviation; p-significance set at level p<.05.

Table 4 shows that female volleyball players generally rate themselves better when compared to other female volleyball players than male volleyball players, in all specific volleyball elements, except when it comes to assessing the quality of relationships with team mates and coaches. However, statistically significant differences were only obtained when it comes to measures of strength such as Serve strength and Physical endurance and strength. Female volleyball players rate themselves as weaker in two domains when compared to male volleyball players of the same age than when compared to female volleyball players.

DISCUSSION

The social understanding of sport as a male domain impedes the entry of girls into certain sports characterized as typically male, and further impedes and affects the motivation of girls to pursue sports. Gender stereotypes refer girls to academia and boys to strength development within sports (Vealey & Chase, 2016), which causes both genders to suffer certain consequences and have reduced opportunities. Within sport, different values are nurtured in relation to the gender of the athletes, so the importance of team play, interpersonal relationships is emphasized in women's sports, while the need for and importance of competence is emphasized in men's sports. This creates an environment where women are sent the message that sport is a domain in which they should not strive to achieve high results, while it creates pressure among men, especially young men, where failure in the sports domain causes ridicule and rejection from others, which contributes to the evolvement of a negative self-image (Vealey & Chase, 2016).

On the other hand, in addition to individual stereotypes and sports perceptions that sports professionals have, sports institutions that finance the realization of sports activities also have a stereotypical understanding of sport, as do the media. The data point to significant differences in the financial support of women and men's sports, as well as in media representation. Thus, women's sports clubs receive 10% of the total funds earmarked for sports, while men's sports clubs receive 61% and mixed clubs 29% of the budget of AP Vojvodina (Đorđić et al., 2013). Men's sports are largely media-driven, unlike women's sports which are invisible to the media despite sport achievements. The lack of media coverage of women's sports, as well as the invisibility of women's role models in sports, affect girls' interest in sports (Đorđić et al., 2013a), as well as their confidence and perceptions of personal performance in the field of sport in relation to men.

The issue of the influence of gender stereotypes on the performance and development of athletes has been explored in the context of identifying stereotypes about women and men's sports and the impact of these stereotypes on self-efficacy (self-assessment of personal performance), motivation and participation in sport (Chalabaev et al., 2012). When it comes to the influence of stereotypes on the development of self-image, motivation and participation in sport, researchers have been guided by Bem's gender model (Bem, 1981) and Eccles' expectancy-value theory (Eccles et al., 1983). Both models assume that stereotypes of the environment and significant others influence the individual by internalization in the personal self during the process of socialization (Chalabaev et al., 2012). In fact, stereotypes influence how an individual perceives himself/herself, and therefore how he/she behaves.

Perceptions and beliefs about one's own performance in sport have proven to be significant factors in sports performance (Moritz, Feltz, Fahrbach, & Mack, 2000), as well as in continuing to do sports (Guillet et al., 2002; Enoksen, 2011).

The current results are, first and foremost, one of the first steps in the prevention of dropping out of sports in adolescence, since girls are at a greater risk of quitting sports compared to boys (Guillet et al., 2002). Between 25% and 50% of female athletes, ages 13-17, drop out of sports annually (Craike, Symons, & Zimmermann, 2009; Møllerløkken, Lorås, & Pedersen, 2015). If taken into account that one top and outstanding athlete is selected from 10000 children (Jevtić, 2011), it is necessary to work on encouraging and preventing young girls from dropping out, both for their individual development and for the creation of top teams and high sporting achievements. Therefore, examining how female athletes view themselves is a step in advancing women's sports.

In Study 1, it has been shown that female soccer and volleyball players competing in the highest rank in Serbia rate themselves as less successful players than male players who practice the same sport at the same rank. These results indicate that female top athletes in Serbia have low self-evaluation of their sports performance. The differences obtained may be due to gender stereotypes in sports. According to Bandura's theory of self-efficacy (Bandura, 1977) and Eccles' expectancy-value theory (Eccles et al., 1983), the beliefs and behavior of the environment and significant others shape the way a person perceives himself/herself and his/her abilities. By internalizing gender stereotypes that sport is primarily a male category of physical activity, female athletes form an image of themselves and their abilities in relation to the evaluation of male sport. Namely, if the sports and social environment creates gender stereotypes in which women in sport should not be directed towards achievement, but towards the development of interpersonal relationships, it directly affects the perception of women's sport, and above all the perception of women athletes.

The different forms of socialization of boys and girls have been conveyed in the domain of sports. Thus, boys are directed toward sports to develop motor skills, physical strength, and achieve significant sporting success, while girls are directed toward sports to develop good posture and good body appearance. Differences are also observed in the period when parents begin to work on developing their children's motor skills. The sensitive period for the acquisition of basic motor skills is from age two to eight (Vealey & Chase, 2016). However, girls are taught basic motor skills later compared to boys, thus maintaining a stable difference in the motor skills of boys and girls in later years (Vealey & Chase, 2016). These differences in the training process of motor skills between boys and girls are in line with the results of Study 2.

When looking at the results of Study 2 (Table 4), although statistically significant differences in self-assessment were obtained when it comes to the serve strength and physical endurance and strength, results in global show that there is a significant distinction in the evaluation of sports efficiency in girls in relation to gender. The results support the assumption that the way girls and boys are coached depends on the gender of the athletes. Girls view themselves as more capable within interpersonal relationships, as previous studies have shown (Vesković, Valdevit, & Đorđević-Nikić, 2013). This indicates that within organized youth sports, and in the case of promising young female athletes who should become professional volleyball players, focus is in on developing social skills through sport. Earlier research has noted that girls evaluate themselves as less physically competent and score lower on scales related to physical self-assessment, but as more socially competent (Kalaja et al., 2009; O'Connor et al., 2020). In this study, girls estimated they were weaker in physical elements than boys too, primarily in elements that require strength. Encouraging boys to be strong and girls to be cooperative leads to this discrepancy.

As mentioned above, the social understanding of sport as a male domain makes it difficult for girls to enter certain sports characterized as typically male, and further influences girls' motivation to continue playing sports. Girls are directed towards academia, with an emphasis on education, and consequently, girls mention school responsibilities and higher levels of education as priorities over sports (Vealey & Chase, 2016). Social relationships become more relevant and girls are stimulated to form and maintain interpersonal relationships in and out of sport.

Despite the fact that there are gender-based differences in the maturation and physical characteristics of boys and girls, what needs to be taken into consideration when creating a training process for boys and girls are that the differences in the treatment of boys and

girls are often not conditioned by genetic and physical predispositions, as much as social and cultural norms. Previous studies have shown different behavior of coaches and parents towards girls and boys in sports. Thus, girls who practice sports are more likely to perceive that parents, coaches and teammates create a task-oriented motivational climate than boys (White, Kavassanu, & Guest, 1998; Vazou, Ntoumanis, & Duda, 2006; Vesković et al., 2013). Coaches in women's sports emphasize the significance of cooperativeness and teamwork, while they emphasize the importance of achievement in men's sport. Thus, girls perceive themselves to be less athletic competent in relation to boys (Van Wersch, Trew, & Turner, 1990), but to a greater extent socially competent (Tubić, Đorđić, & Poček, 2012).

The results of Study 1 and Study 2 show that differences in self-assessment (in general physical abilities and specific motor abilities) exist at different levels of competitive rank. Self-assessment of specific motor skills (Study 2) can be an indicator of the first steps of development of poorer self-assessments of the general physical abilities of female athletes. If female athletes perceive that they are less competent then male athletes in specific motor skills needed for success in their sports, over time they will develop a general belief about their physical abilities.

CONCLUSION

The results obtained call for further exploration of the concept of self-efficacy and competence of female athletes. Although the research sample is small, it has included top female athletes, as well as promising female athletes (cadets and juniors). The way they see themselves as athletes professionally engaged in sports can be used in order to rethink the training process and approach to women's sports in order to improve self-confidence in women, as well as the factors contributing to the creation of a positive or negative self-image in sports.

Finally, further research is needed to examine gender differences in the assessment of athletic ability.

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SAMOPERCEPCIJA SPORTSKIH SPOSOBNOSTI SPORTISTKINJA U POREĐENJU SA SPORTISTIMA ISTOG I SUPROTNOG POLA

Cilj ove studije je da se utvrdi kako fudbalerke i odbojkašice najvišeg nivoa, kao i mlade odbojkašice, kadetkinje i juniorke, vide sebe, svoje sposobnosti i svoje specifične motoričke sposobnosti u sportu u odnosu na druge sportiste i sportistkinje. U studiji 1 uzorak je sačinjavalo 24 vrhunskih fudbalerki i odbojkašica najvišeg sportskog ranga u Srbiji. U studiji 2 uzorak je sačinjavalo 31 odbojkašica, kadetkinja i juniorka. Sve su popunile kratki upitnik u vezi sa samopoimanjem njihovih sportskih sposobnosti u poređenju sa sportistima istog i suprotnog pola, istog ranga, sporta i starosti. Rezultati studije 1 pokazuju da fudbalerke i odbojkašice sebe doživljavaju kao manje kompetentne u poređenju sa muškim sportistima istog sporta i uzrasta (t (22)=5.97, p=.00). Rezultati Studije 2 pokazuju da kadetkinje i juniorke odbojkašice sebe doživljavaju kao manje kompetentne u Snazi servisa (t (29)=3.27, p=.030) i Fizičkoj izdržljivosti i snazi (t (29)=2.52, p=.017) u poređenju sa odbojkašima istog sporta i uzrasta. Dobijeni rezultati zahtevaju dalje ispitivanje rodnih razlika u u samopercepciji kompetentnosti.

Ključne reči: *Sportistkinje, Samopercepcija, Kompetencija, Fudbal, Odbojka*.

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Research article

PHYSICAL EDUCATION AND MUSIC EDUCATION IN THE CONTEXT OF THE POSSIBILITY OF USING THE INTEGRATED LEARNING APPROACH AS A REFLECTION OF MODERN SOCIETY

UDC 796.371.212 (532)

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Abstract. *The goal of this paper is to find and examine an effective methodological model that would enable students to adopt the learning content of children's folk dances accompanied by singing more successfully, and to develop a better sense of coordination, through the integration of Physical Education and Music Education. An experimental method with two parallel groups (EG – experimental and CG – control group) was applied. The experimental program was based on the recommended learning topics including children's folk dances accompanied by singing for the subjects Music Education and Physical Education. The integrated approach was applied with the students from the EG in learning about children's folk dances accompanied by singing, while the traditional learning approach was used with the students from the CG (they did not learn about the children's folk dances accompanied by singing through the integrated learning approach). In this research, a testing technique was applied with the students from both the EG and CG in order to check the level of coordination, and the instruments used were the Coordination Ability Assessment. The results obtained indicate that the students from the EG showed better coordination skills compared to the students who were not included in the experimental program. It is important to emphasize that the results obtained proved the connection between physical abilities and movement techniques in children's folk dances accompanied by singing, which supports the need to start with coordination practice as early as possible in primary school, which will bring good results in individuals' life later on.*

Key words: *Physical Education, Integrated Learning, Learning Topics, Music Education, Modern Society.*

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INTRODUCTION

A scientific analysis of the education process under the conditions of modern society and contradictory globalization is not an easy job at all. That general knowledge, or the reflection on the consequences of the second wave of modernization, as well as the modernization of the education process, is as complex and subject to accelerating change as Serbian society itself. There is a danger that the empirical studies and recent theoretical considerations from the second decade of the third millennium will be overcome very soon due to the pace of change taking place in modern society. On the other hand, it is very difficult to draw the line and interpret the importance of social changes that the school is ready to embrace through the process of education and thus integrate young generations into the global social, cultural, political and economic subsystems (Jovanović & Zdravković, 2017). The latest trends in modern education show that there is an increasing aspiration to acquire interdisciplinary knowledge which, among other things, relies on integrated and synthetic approaches, which proves that education is adopting the social implications of the fourth industrial revolution. Modern society strives to integrate knowledge by using the interdisciplinary relations, which should allow for a worldview that focuses both on integrity and ambiguity. Such education stimulates the growth of creative potential in students. The role of integrated learning in these processes is very important, because its successful implementation will be more feasible if the course materials are freed from excessive subject differentiation, and if the integration of knowledge is embraced.

Integrated learning is an innovated model which interconnects learning topics from two or more subjects, in order to provide an adequate response to the reflections of the modern age. This teaching model erases the boundaries between different subjects. This is particularly true for the modern teaching of Music Education and Physical Education, whose curricula include similar learning topics. Therefore, new, modern types of learning need to be provided, and integrated learning is one of them. With the integrated connection of similar learning topics from the Music Education and Physical Education course, a large number of learning objectives can be achieved.

Relevant methodological references (Mejovšek, 1961; Đorđević, 1971; Stojanović, 1996; Bratić & Filipović, 2001; Kragujević, 2005; Momčilović & Momčilović, 2013; Jeremić & Stanković, 2019) indicate that there is the possibility of connecting and linking the learning topics of the Music Education and Physical Education courses, with regards to children's folk dances accompanied by singing. Since this issue has so far been studied only from the perspective of each subject separately, there are no scientific facts about the effect of the integrated learning approach on the development of coordination skills in younger school-age students. The main motive that initiated the empirical research in this paper was the fact that there is not enough focus in the domestic literature on children's folk dances accompanied by singing, and the fact that there are numerous possibilities to use this learning topic in Music Education and Physical Education lessons, and that the curriculum includes certain learning objectives which relate precisely to the issue in question.

The inconsistency between the Music Education curriculum which includes the learning topics of music performing, singing and music games, and Physical Education curriculum that includes rhythmic exercises and folk dances, results in the fact that children find it difficult to adopt these learning topics if they are presented within each course, separately, and not by using the integrated learning approach. These facts justify

our efforts to examine the integrated interdependence of children's folk dances accompanied by singing and their impact on the development of coordination at a younger school age.

This research is important because it attempts to find an efficient methodological model that would enable students to adopt the learning content of children's folk dances accompanied by singing more successfully, and to develop a better sense of coordination through the integration of physical and music education. When we talk about the development of coordination in students, it is important to take into account the sensitive phases of development, since the younger primary school age is the period when children's development can be influenced the most, which indicates when to start with the targeted development of this ability (Lazarević, Milosavljević, Lazarević, Marković & Savić, 2018).

As our field of interest in this study is focused on the development of coordination at a younger school age, we use children's folk dances accompanied by singing and their impact on the development of coordination at a younger school age, and by reviewing the available references (Jocić, 1991; Kostić, 1994; Vlašić, Oreb, & Furjan-Mandić, 2007; Oreb, Vlašić, & Zagorac, 2011) it can be concluded that there has been no research that approaches this topic from an integrated learning aspect. This research is justified by the fact that the studies conducted so far have mainly focused on the connection between folk dances and primary motor skills. None of these papers dealt with children's folk dances accompanied by singing and their effect on the development of coordination at a younger school age.

The goal of this paper is to find and examine an effective methodological model that would enable students to adopt the learning content of children's folk dances accompanied by singing more successfully, and to develop a better sense of coordination, through the integration of Physical and Music Education.

METHODS

For the purposes of this paper, an experimental method with two parallel groups (experimental group-EG and control group-CG) was applied. The experimental program was based on the recommended learning topics including children's folk dances accompanied by singing for the subjects Music Education and Physical Education, according to *the Rulebook on the curriculum for the first and second grade of primary education* (2004), as well as the current *Rulebook on the curriculum for second grade of primary education* (2018). Ten learning topics were taught, once a week: *Kolariću, Paniću [Cat's cradle]*; *Hajd na levo [Hop to the left]*; *Poslala me mila mati [My dear mother sent me here]*; *Ja posejah lubenice [I planted the watermelons]*; *Dunje ranke [Fresh Quince]*; *Mitku noge zaboleše [Mitka's Legs Hurt]*; *Lepa Anka [Pretty Anka]*; *Igra kolo u pedeset i dva [Cirle folk dance]; Prolećno kolo [Spring circle dance]*; *Mi smo deca vesela [We are happy children]*. The integrated approach was applied with the students from the EG in learning about children's folk dances accompanied by singing, while the traditional learning approach was used with the students from the CG, which means that they did not have the opportunity to learn about the children's folk dances accompanied by singing through the integrated learning approach. In this research, a testing technique was applied with the students from both the EG and CG in order to check their level of coordination, and the instruments used were the Coordination Ability Assessment, which consisted of the following tests: the obstacle course backwards, three-ball slalom, non-rhythmic hand tapping, and hand and foot tapping. The selection of coordination tests for the younger school-age students is a big issue because there is

relatively little research that tried to identify the metric characteristics on a sample of tests used in testing students of that particular age. Therefore, the coordination tests we chose for this study have a good validity that has already been proven in several larger studies (Gredelj, Metikoš, Hosek, & Momirović, 1975; Kurelić et al., 1975; Metikoš, Gredelj, & Momirović, 1979; Metikoš, Prot, Hofman, Pintar, & Oreb, 1989; Bala, 1981, 1999, 2007). The instruments were taken from a battery of tests for the assessment of coordination, which was first used in the research conducted by Gredelj and associates in 1975. For the purposes of the research conducted by Kostić (1986), the instruments Obstacle course backwards and Three-ball slalom were slightly modified and thus adjusted to the younger school age students – participants in the study. The Obstacle course backwards test was modified so that the track was shortened from 10 meters to 6 meters, while in the Three-ball slalom test, the track was shortened from 10 meters to 8 meters. These modified tests are suitable for the age of the participants in our research, and we will use them as such.

Coordination tests were performed in the gymnasium in conditions of good lighting and temperature. During the coordination test, the students wore sports equipment, intended for physical education classes. Before the measurement was started, the examiners (physical education teacher and authors of this research) demonstrated to the participants how to perform the test several times. After the demonstration of the test by the examiners, each student was assessed separately.

There was a separate measurement sheet for each student, where the results of the coordination assessment were entered.

We used Cronbach's alpha coefficient of reliability to calculate the reliability of the coordination tests used on students attending the second grade of primary school. All the subscale values of the Coordination Assessment have Cronbach's alpha coefficient values above 0.700, which means that they are reliable and range from 0.756 to 0.903.

At the very beginning of the research, the students did an initial test (the initial and final tests were identical) whose purpose was to provide insight into the starting coordination skills in students in both the EG and CG.

After the experimental program was completed with the students of the EG and CG, the final test was given to them (the initial and final tests were identical), the purpose of which was to determine:

(1) whether and to what extent the students from the EG progressed in terms of the development of coordination compared to the initial test they took?

(2) whether there is a difference in the results achieved between the students from the EG and CG after the implementation of the experimental program?

As coordination skills are not innate, but are developed through learning (Malacko, Stanković, Doder, & Pejčić, 2015), the studies related to the training of children and youth (Weineck, 1996 according to Crnokić, 2010) the focus is on the development of coordination skills in children aged between 7 and 12. This particular data affected our choice of the age of our study participants, which was between 8 and 9 years of age, that is, second graders. The research sample was selected from the students who attended the second grade of primary school in the city of Vranje in 2015/2016. The total number of students who participated in the research was 173. It should be emphasized that in each phase of the research a certain number of students were absent from school and that these students could not be tested additionally, which is why the final sample included only those students who were in class on the days when both initial and final testing were carried out. Therefore, the valid sample consists of 162 students. The EG consisted of 80 students from four classes of

the primary school "Jovan Jovanović Zmaj" from Vranje. The CG of students consisted of 82 students from four classes of the primary school "Vuk Karadzić" in Vranje.

Data analysis showed that the EG and the CG were identical from the aspect of the sample structure (χ^2=0.025, df=1, p=0.875). Moreover, 49.38% of the study participants were in the EG, while 50.62% of the participants were in the CG.

Statistical analysis of data was performed by using the computer program SPSS ver. 21 (Statistical Package for the Social Sciences). The level of statistical significance was defined at the level of probability from $p \leq 0.05$ to $p < 0.01$. The following statistical tools were used for data analysis:

- Identifying descriptive characteristics: *mean value (M)* and *standard deviation (SD)*, maximum and minimum;
- The differences between the groups were determined using the Analysis of variance (ANOVA);
- Repeated Measures Analysis of Variance was used to examine the differences between two measurements on the same subjects;
- Analysis of covariance (ANCOVA) was used to examine the difference between the EG and CG, with the effect of the initial measurement removed.

RESULTS

Comparative results of the initial measurement of the level of coordination skills in the EG and CG

Before the implementation of the experimental program, the test for the assessment of coordination in students attending the second grade of primary school determined the initial level of their coordination skills. The results obtained are shown in Table 1.

Table 1 Results of measuring the initial state of coordination in the EG and CG

	Group	N	M	SD	F	p
Obstacle course backwards	EG	80	16.9515	4.92581	-.160	.873
	CG	82	16.8288	4.81431		
Three-ball slalom	EG	80	.9675	.33427	-.183	.855
	CG	82	.9583	.30704		
Non-rhythmic hand tapping	EG	80	7.8625	2.38531	-.395	.694
	CG	82	7.7195	2.22375		
Hand and foot tapping	EG	80	6.9998	1.65812	.301	.764
	CG	82	6.9756	1.53941		

Legend: N-number of participants; M-Mean (the average value of the variable in the sample); SD-Standard deviation (the average deviation of the individual variable values from the average in the sample); F-Analysis of variance (ANOVA); p-statistical significance

Comparisons were made for all four coordination tests in the EG and CG. The results have shown that there was no statistically significant difference between the EG and CG in the coordination tests.

The average time it took the EG to complete the Obstacle course backwards test was M=16.9 s, and for the CG M=16.8 s (F=-.160, p=.873). The average time it took the EG to take the Three-ball slalom test was M=0.96 s, and for the CG M=.95 s (F=-.183, p=.855). The average number of correctly performed cycles in the Non-rhythmic hand tapping test by the EG was M=7.86, and by the CG M=7.71 (F=-.395 p=.694). The average number of correctly performed cycles in the Hand and foot tapping test by the EG was M=6.90, and by the CG M=6.97 (F=.301, p=.764). The statistical significance was above the value of 0.05, so we can conclude that the participants from the EG and CG had the same results on all coordination tests.

Comparative results of the initial and final measurements of the level of coordination skills in the CG

In order to get the objective data on the level of coordination skills in the CG, we analyzed the data obtained during the initial and final testing. The results of the final testing of the level of coordination in the students from the CG shown in Table 2 indicate that certain changes are evident, but that they are not statistically significant.

Table 2 The results of the initial and final measurements of the level of coordination skills in the CG

Control group		N	M	SD	F	p
Comparison 1	INITIAL, Obstacle course backwards	82	16.8288	4.81431	1.027	.308
	FINAL, Obstacle course backwards	82	16.1406	3.41011		
Comparison 2	INITIAL, Three-ball slalom	82	.9583	.30704	3.586	.071
	FINAL, Three-ball slalom	82	.8500	.30374		
Comparison 3	INITIAL, Non-rhythmic hand tapping	82	7.7195	2.22375	.894	.374
	FINAL, Non-rhythmic hand tapping	82	7.9178	2.14444		
Comparison 4	INITIAL, Hand and foot tapping	82	6.9756	1.53941	-.961	.339
	FINAL, Hand and foot tapping	82	7.1463	1.65643		

The results show that there is no statistically significant difference in any of the four coordinated tests.

For the Obstacle course backwards test (F=1.027, p=.308) and the Three-ball slalom test (F=3.586, p=.071), the time to perform the task was shorter (the average mean value proves this), while in the Non-rhythmic hand tapping test (F=.894, p=.374) and the Hand and foot tapping test (F=.961, p=.339) the number of correctly performed cycles increased.

Comparative results of the initial and final measurements of the level of coordination skills in the EG

Since the intention of this research was to also examine the effects of the implementation of the experimental program on the development of coordination skills in students, Table 3 shows the results of the students at the initial and final measurement as part of the coordination test.

Table 3 The results of the initial and final measurements of the level of coordination skills in the EG

Experimental group		N	M	SD	F	p
Comparison 1	INITIAL, Obstacle course backwards	80	16.9515	4.92581	3.039	**.003**
	FINAL, Obstacle course backwards	80	15.1842	3.01458		
Comparison 2	INITIAL, Three-ball slalom	80	.9675	.33427	6.916	**.000**
	FINAL, Three-ball slalom	80	.6513	.29822		
Comparison 3	INITIAL, Non-rhythmic hand tapping	80	7.8625	2.38531	-23.386	**.000**
	FINAL, Non-rhythmic hand tapping	80	9.3625	2.40907		
Comparison 4	INITIAL, Hand and foot tapping	80	6.9998	1.65812	-25.437	**.000**
	FINAL, Hand and foot tapping	80	8.6375	2.04533		

Based on the results obtained, we can conclude that there is a statistically significant difference between the results on the initial and the final coordination test taken by the EG. The statistical significance of this test shows that a statistically significant difference exists for all coordination tests: the Obstacle course backwards (F=3.039, p=.003), Three-ball slalom (F=6.916, p=.000), Non-rhythmic hand tapping (F=-23.386, p=.000) and Hand and foot tapping (F=-25.437, p=.000).

Based on the mean values we can conclude that the time to perform the tasks from the Obstacle course backwards test and the Three-ball slalom test during the final testing was shorter than it was during the initial testing, while the Non-rhythmic hand tapping test and the Hand and foot tapping test also showed an increased number of correctly performed cycles. The final test results were better that the results achieved on the initial test. The data show that the impact of the experimental program had a statistically significant effect, which resulted in progress in the students' level of coordination.

Comparative results of the final measurements of the level of coordination skills in the EG and CG

We wanted to determine with the final measurements, whether or not there is a statistically significant difference in the level of coordination of students from the two examined groups at the end of the experimental program. After completing the experimental program, the students from both the EG and CG took the same test they already did in the initial testing.

Table 4 shows the results of the final measurements in the coordination test for both groups.

Table 4 The results of the final measurements of the level of coordination skills in the EG and CG

	Group	N	M	SD	F	p
Obstacle course backwards	EG	80	15.1842	3.01458	1.939	**.049**
	CG	82	16.1406	3.41011		
Three-ball slalom	EG	80	.6513	.29822	2.933	**.004**
	CG	82	.8500	.30374		
Non-rhythmic hand tapping	EG	80	9.3625	2.40907	-5.235	**.000**
	CG	82	7.9178	2.14444		
Hand and foot tapping	EG	80	8.6375	2.04533	-5.105	**.000**
	CG	82	7.1463	1.65643		

When we compare the achievements of students from the EG and the achievements of students from the CG on the final test aimed to assess their level of coordination skills, we can see that students from the EG achieved significantly better results than the students from the CG. The results have shown that there was a statistically significant difference between the EG and CG in favor of the EG in all four coordination tests: the Obstacle course backwards, Three-Ball Slalom, Non-rhythmic hand tapping, and Hand and foot tapping.

The average time it took the EG to complete the Obstacle course backwards test during the final measurement was M=15.2 s, and for the CG M=16.1 s (F=1.939, p=.049). It should be noted that the statistical significance for the Obstacle course backwards test results is close to the limit value of 0.05 - it is not at the limit value itself, but it is very close. Therefore, since there is a statistically significant difference, we can conclude that the EG completed this test within a shorter period of time.

The average time it took the EG to take the Three-ball slalom test was M=0.65 s, and the CG M=0.85 s (F=2.933, p=.004). Therefore, as there is a statistically significant difference present here is well, we can conclude that the EG completed this test within a shorter period of time during the final measurement.

The average number of correctly performed cycles in the Non-rhythmic hand tapping test by the EG was M=9.36, and by the CG M=7.91 (F=-5.235, p=.000). The value which is below the limit value of 0.05 indicates that there is a statistically significant difference. Based on the obtained findings, it can be concluded that the participants from the EG had more correctly performed cycles compared to the CG during the final measurement.

The average number of correctly performed cycles in the Hand and foot tapping test by the EG was M=8.63, and by the CG M=7.14 (F=-5.105, p=.000). The statistical significance is lower than the limit value of 0.05, so we can conclude that the participants from the EG had more correctly performed cycles compared to the CG during this final measurement as well.

Analysis of the differences between the EG and CG in the level of coordination skills with the effect of the initial measurements removed

In order to present the obtained results as clearly as possible, we wanted to be sure that the differences between the EG and CG regarding the level of coordination skills were the result of the implemented experimental program, and not the influence of the initial differences. Let us assume that it is possible that the EG has a better performance on the initial test that assessed coordination, and therefore better final results. In that case, better achievement did not happen because of the influence of the experimental program, but because of the initially better results. In order to eliminate such doubts, we used the Analysis of covariance (ANCOVA) to mathematically remove the effect of the initial measurements (covariance). Table 5 shows the differences between the EG and CG in the level of coordination skills, with the effect of the initial measurement removed.

Table 5 The differences between the EG and CG in the level of coordination skills, with the effect of the initial measurement removed

	F	p	η^2
Obstacle course backwards	3.961	**.051**	.052
Three-ball slalom	8.745	**.004**	.108
Non-rhythmic hand tapping	50.364	**.000**	.241
Hand and foot tapping	66.883	**.000**	.296

Legend: F-multivariate F value; p-the statistical significance of the univariate and multivariate F-test; η^2-Eta-squared (measure of effect size).

After the statistical elimination of the effect of the results of the test performed before the introduction of the experimental program in the EG, it was found that there was a statistically significant difference between the EG and CG in the results on all four coordination tests: the Obstacle course backwards, Three-ball slalom, Non-rhythmic hand tapping, and Hand and foot tapping. Therefore, after removing the influence of the initial test, the EG and CG had different achievements on the final test. Namely, the participants from the EG showed a higher level of coordination skills compared to the participants from the CG. What caused these differences the most, as indicated by the η^2 measure of effect size, were the variable Hand and foot tapping with 29%, and Non-rhythmic hand tapping with 24%. The variable Three-ball slalom, with approximately 11% had an average impact, and the smallest impact was expressed through the variable Obstacle course backwards, with a little more than 5%.

Based on the results obtained, it can be concluded that we have proven the assumption that the students from the EG among which the integrated learning approach was applied would achieve a higher level of coordination skills compared to the students who were not included in the experimental program.

DISCUSSION

The main aspect of our research was related to the assessment of a basic motor skill - coordination. The assessment of the level of coordination skills was performed with four tests: the Obstacle course backwards, Three-ball slalom, Non-rhythmic hand tapping, and Hand and foot tapping test. The results after the implementation of the experimental program show significantly better results for the parameters in the EG compared to the CG. The EG showed greater progress on all four coordination tests compared to the initial testing, while the CG showed some progress too, but to a lesser extent. What caused these differences the most, as indicated by the η^2 measure of effect size, were the variable Hand and foot tapping with 29%, and Non-rhythmic hand tapping with 24%. The variable Three-ball slalom, with approximately 11% had an average impact, and the smallest impact was expressed through the variable Obstacle course backwards, with a little more than 5%.

It can be assumed that the changes that occurred in the EG are the result of the integrated learning approach in teaching children's folk dances accompanied by singing and a more intensive learning efforts in the EG.

Compared to the initial measurement of the CG of students, the results of the coordination abilities test show that there were no statistically significant changes under

the influence of the learning topics covered in regular physical education and music education classes.

Studies conducted by various authors (Krsmanović, 2000; Zrnzević, 2007) have shown that regular physical education classes are not efficient enough and that more positive effects can be achieved with various additional learning topics regarding natural movements, dance forms and additional exercises.

Due to the proven connection between, on the one hand, the anthropological characteristics and on the other hand, the technique of movement in children's folk dances accompanied by singing, it is necessary to start with the development of coordination early in childhood, which will bring good results in individuals' life later on (Hošek, 1976; Malacko, 2002).

Based on the results obtained, it can be concluded that the students from the EG in which the integrated learning approach was applied would achieve a higher level of coordination skills compared to the students who were not included in the experimental program. Based on the results of our research, which are in line with the findings confirmed in the previous hypothesis, we emphasize that the teaching process based on the integrated learning approach and organized so that students are provided with the knowledge from the related learning topics and courses, will allow the student to achieve better results on aptitude tests than those students who learn following the traditional way of learning (Lake, 1994; Mathison & Freeman, 1997).

CONCLUSION

It has been proven that there are music-related learning contents in the curriculum that can be taught along with the related contents from other subjects in class teaching, by using the integrated learning approach. Such contents include children's folk dances accompanied by singing, which are inextricably linked with the Physical Education course. For that reason, during the development of curricula, it would be wise to highlight such learning topics that would be adequate for the implementation of integrated teaching. In that case, the timing would have to be taken into account, because certain learning topics that are related and connected should be planned in the approximate time in order to facilitate the organization and implementation of such a teaching model for teachers. This type of teaching allows the teachers use time rationally, because they do not have to repeat certain topics several times; moreover, the students get a broader picture of the learning topics, which enables them to connect them more easily, understand more clearly and have more lasting knowledge.

It is evident that children's folk dances accompanied by singing have succumbed to the abundance of seemingly more interesting music that is spread by various media. Since the school can be a significant factor in preserving folk traditions and nurturing traditional values, the innovated teaching models, better organization of the teaching process, more adequate teaching aids, more modern sources of knowledge, and new scientific knowledge can make something old become more attractive to younger school-age students. Traditional music learning topics, such as children's folk dances accompanied by singing, should not be a problem for both teachers in the teaching process and the students in their understanding, accepting and adopting of such topics. Such learning topics should be the

starting point in the development of elementary music and physical abilities, but also an important part of the general music and physical culture.

Since this research has proven the benefits of the application of integrated learning approach in teaching children's folk dances accompanied by singing, it is important to point out that the integration in the classroom implies not only a different way of learning, but also a different way of teaching, and from that aspect, the teacher has a crucial role and responsibility since they lead the teaching process. Therefore, the question arises as to how trained the teachers are to apply the integrated learning approach. Although the teachers often state that they do not have enough time to plan and implement integrated learning, and that the curriculum discourages this, it still seems that their didactic and methodological skills and knowledge required to implement such a model of teaching is the biggest issue. In that sense, there is a need for the continuous professional development of teachers, which can be realized through seminars that would deal with the issue of integrative teaching. Hence, there is a need for the continuous professional development of teachers, which can be achieved through seminars that would deal with the issue of integrated learning.

Teachers' teamwork is another important link with regards to planning, organizing and implementing learning topics based on the integrated learning model. In that sense, it is necessary to organize respectable and demonstration classes taught per the integrated learning model, where the teachers would acquire the necessary knowledge that would allow them to apply the integrated learning model in the classroom.

In addition to all the above, it is important to mention that based on the theoretical and empirical findings of this research, and especially on the results obtained after implementing the integrated learning model to teach children's folk dances accompanied by singing, new questions have arisen which should trigger further research in this field:

1. Identify the effect of the experimental factor on encouraging coordination development from the first to the fourth grade of primary school. Our research included second grade students. The implementation of the integrated learning model when teaching children's folk dances accompanied by singing from the first to the fourth grade would bring a better insight into the effects of the experimental factor;
2. Identify the effect of the experimental factor on other basic motor skills (strength, endurance, speed, flexibility, balance and precision).

Through related learning topics, this paper has merged two courses from our educational system and thus given guidelines on how to innovate the teaching process, that is, how to find effective methodological approaches to encourage the development of basic physical abilities in students.

The obtained findings on the effects of the applied experimental program in teaching Physical Education and Music Education at a younger school age speak in favor of the possibility to apply the integrated learning approach in the teaching process, despite certain material and organizational difficulties that our schools face.

The significance of this research is reflected in the data showing the possibilities and limitations of the implementation of the integrated learning model in the existing type of organization of teaching. From the didactic and methodological aspect, the importance of this research is reflected in the confirmation of the efficiency of application of the integrated model of teaching. Moreover, the results obtained can be used to design and review related learning topics in a more comprehensive way, unlike the traditional way of teaching, without deviating from the learning topics and teaching units which are determined by the Curriculum. From the aspect of physical and music education, the

importance of this research is reflected in the fact that the efficiency of application of this learning model in teaching children's folk dances accompanied by singing was confirmed, and the results of this research, which had an experimental and empirical character, provided the information on developmental characteristics regarding the basic motor skills of coordination in students of the second grade of primary school. Children's folk dances accompanied by singing, as an inseparable segment of folk music, should have a more significant place, viewed from the aspect of sociology of sports, in order to significantly influence the enhancement of general knowledge and understanding of the importance of preserving traditional heritage during primary school education.

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FIZIČKO VASPITANJE I MUZIČKA KULTURA U KONTEKSTU MOGUĆNOSTI PRIMENE INTEGRATIVNOG PRISTUPA KAO REFLEKSIJE SAVREMENOG DRUŠTVA

Cilj ovog rada je ispitivanje efikasnog metodičkog modela koji bi omogućio da učenici, kroz integraciju fizičkog i muzičkog obrazovanja, uspešnije usvajaju nastavne sadržaje dečje narodne igre sa pevanjem, te da efikasnije razvijaju osećaj za koordinaciju, kroz integraciju Fizičkog vaspitanja i Muzičke kulture. Za potrebe ovog rada primenjena je eksperimentalna metoda sa dve paralelne grupe (EG – eksperimentalna i KG – kontrolna). Eksperimentalni program koncipiran je na osnovu preporučenih sadržaja dečje narodne igre sa pevanjem za predmete Muzička kultura i Fizičko vaspitanje. Sa učenicima EG primenjen je integrativni pristup u obradi sadržaja dečje narodne igre sa pevanjem, a sa učenicima KG nastava je realizovana na klasičan način (oni nisu imali priliku da integrativnim modelom učenja usvoje nastavne sadržaje dečje narodne igre sa pevanjem). U ovom istraživanju primenjena je tehnika testiranja koja je izvršena sa učenicima EG i KG u cilju provere nivoa razvijenosti koordinacije, a od instrumenata primenjen je Test procene

sposobnosti koordinacije. Dobijeni rezultati ukazuju na to da učenici iz EG u kojoj je primenjen integrativni metodički pristup pokazuju viši nivo razvijenosti koordinacije u odnosu na učenike koji nisu obuhvaćeni eksperimentalnim programom. Značajno je naglasiti da su dobijeni rezultati dokazali povezanost fizičkih sposobnosti i tehnike kretanja u dečjim narodnim igrama sa pevanjem, što ukazuje na opravdanost potrebe da se što ranije u osnovnoj školi krene sa razvojem koordinacije, što će dati solidne individualne rezultate u kasnijoj životnoj dobi ispitanika.

Ključne reči: *fizičko vaspitanje, integrativna nastava, nastavni sadržaji, muzička kultura, savremeno društvo.*

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Research article

THE INFLUENCE OF TEACHER-STUDENT COMMUNICATION ON THE IMPORTANCE OF PHYSICAL EDUCATION

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Abstract. *During adolescence, there is a significant risk of sports abandonment associated with sedentarism and overweight. For this reason, Physical Education (PE) classes should be an opportunity to bring physical activity and sport closer to schoolchildren developing, and consolidating healthy lifestyle habits. Considering the importance that teaching communication procedures can have in the motivation of students, and given the lack of specific studies that investigate the influence of these processes on the motivation to practice sport in the context of PE, the aim of this study is to determine the effect of the teacher's communicational dimensions (challenging, encouragement and praise, non-verbal support, understanding and friendliness, and controlling) on the perception of the importance given to PE. The sample was composed of a total of 203 PE students between 10 and 16 years old. The mean (M), standard deviation (SD), skewness (S) and kurtosis (K) of the dimensions of the Teacher Communication (TC) and Importance of Physical Education (IPE) were analysed. In order to determine the relationship between the variables analysed, Pearson's correlation is used. With an aim of determining the effect of the perception of the TC in the classroom on the students' IPE, linear regression is carried out. In data processing, the SPSS 23.0 software is used. The results obtained show that the TC has an effect of 19.7% on IPE. Understanding and friendliness, and controlling dimension are being analysed with the highest standardized regressions coefficient in students' perception of IPE.*

Key words: *Communication Skills, Teachers, Importance of Physical Education.*

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INTRODUCTION

Physical inactivity and obesity are two of the biggest health challenges faced by modern society (Slingerland & Borghouts, 2011). This has become, in recent years, a serious global health problem affecting our young people (Mielgo-Ayuso et al., 2017; Gordon, 2020). To combat this, the promotion and development of physical activity (PA) is essential, as it is associated with several health benefits such as mental health (Biddle, Ciaccioni, Thomas, & Vergeer, 2019), well-being (Costigan, Lubans, Lonsdale, Sanders, & del Pozo Cruz, 2019), fitness (Cvejić, Buišić, Mitrović, & Ostojić, 2018), and the prevention of cardiovascular disease in adulthood (Cooper & Radom-Aizik, 2019). Regardless of the importance of PA for the improvement of health, both at a social and scientific level, the public alarm due to the life habits of the younger generations is rising. Such alarm is not only due to the fact that child obesity is increasing, but also because the physical condition and sports practice of adolescents is in continuous decline (Corder et al., 2019). Sedentarism is one of the main threats facing society today. In fact, a large number of children and adolescents do not follow healthy lifestyle habits related to the recommended minimum daily or weekly PA (Corder et al., 2019). In this context, it is, therefore, crucial to address this problem from different perspectives, with the school context being a privileged environment for implementing strategies both within and outside the curriculum, involving the entire educational community (Love, Adams, & van Sluijs, 2019).

Adolescence is a period in which young people are exposed to a myriad of social, biological, and cognitive changes (Meeus, 2011). There, teenagers try to find or shape their identity, integrating themselves into personal adult relationships, and living with the behavioural problems of life (Meeus, 2016). Given that during adolescence identity is not yet constructed, it is during this period of development when people are most exposed to the acquisition of both healthy and unhealthy life habits. The habits acquired during this period are decisive for the development of healthy lifestyles that can be maintained during adulthood (Viner et al., 2015). Therefore, regular PA in adolescence is essential for a healthy development (Cho & Kim, 2019). In this sense, in view of the dynamism and vulnerability of this period, accompanied by its constant changes, it is important to focus attention on the social context that surrounds the young person.

One of the greatest places of influence on adolescents is school, as it is the place where they learn healthy habits and how each of them is addressed (Grao-Cruces, Loureiro, Fernández-Martínez, & Mota, 2016). Within the school context, it is as part of the subject of Physical Education (PE) where it is possible to have a greater impact on healthy habits. In fact, several studies (Fairclough & Stratton, 2005; Lindgren, Haraldsson, & Håman, 2019; Abula et al., 2020) identify PE teachers as key agenta in influencing the development of healthy habits in PE classes. Both directly, raising proposals in the classes that help to meet adequate levels of moderate and vigorous Physical Activity (MVPA), as well as indirectly, through the transmission of values, knowledge, skills, etc. Since MVPA are decreasing in both sexes from early on, and especially among women (Ridley & Dollman, 2019; Farooq et al., 2020), PE should be considered and used as a unique opportunity to access, act, and approach young people for the development of healthy living habits from an educational, sports, and movement perspective, Furthermore, the entertainment and performance of PE classes is a powerful proponent of PA in young people (Wallhead, Garn, & Vidoni, 2014). The lack of enjoyment and motivation towards PE classes are important elements to be considered, as motivation towards PE classes has been shown to

enhance and encourage PA from early ages to adolescence (Wallhead et al., 2014). Such an important role of motivation, and more specifically, intrinsic motivation, should be considered when organising and planning what kind of programmes and methodologies are introduced and implemented in PE classes to promote an active and healthy lifestyle (Sierra-Díaz, González-Víllora, Pastor-Vicedo, & López-Sánchez, 2019).

On the other hand, so far, several studies have shown how teachers' communication strategies can help students' motivational processes (Armstrong & Hope, 2016; Akudo, 2020). In the case of PE, studies such as the one conducted by Sparks, Dimmock, Whipp, Lonsdale, and Jackson (2015) highlight how teacher behaviours such as teacher communication have a positive impact in students' experiences in PE in areas like mood, class engagement, intrinsic motivation, efficacy beliefs, and leisure-time. Nevertheless, notwithstanding its importance, the use and mastery of teacher communicative skills, both verbal and non-verbal it is sometimes overlooked (Kelly & Sains, 2017).

Considering the importance that teaching communication procedures can have in the motivation of students, and given the lack of specific studies that investigate the influence of these processes on the motivation to practice sport, in the context of PE, the aim of this study is to know the effect of the teacher's communicational dimensions (challenging, encouragement and praise, non-verbal support, understanding and friendliness, and controlling) on the perception of the importance given to PE.

METHOD

Participants

The sample of the present study has a total of 203 students of Secondary Education in an English bilingual school of the *Comunitat Valenciana* (Spain), 54% girls (n=110) and 46% boys (n=93). The ages of the participants are from 10 to 16 years old, corresponding to the courses of the English educational system from *Year 7* to *Year 11*, with an average age of 13.07±1.45 years. Considering extracurricular sports practice, 71% of the students are physically active outside of school hours and 29% were not physically active at any time. The study was carried out in accordance with the Declaration of Helsinki (World Medical Association, 2013).

Instruments

The instrument used in the present study was formed by the Teacher Communication Behavior Questionnaire (TCBQ) created and validated by She and Fisher (2000) which measures students' perception of the type of communication used by teachers in their classrooms (Matos, Leite, Brown, & Cirino, 2014). The TCBQ is composed by 40 items distributed in 5 dimensions. Our sample presents good properties of reliability and validity: *Challenging* (e.g. “This teacher asks questions that make me think hard about things that I have learned in class”) (α= .91), *Encouragement and Praise* (e.g. “This teacher encourages me to express my opinions about a topic”) (α= .89), *Non-verbal Support* (e.g. “Without speaking, this teacher indicates support for me through his/her facial expression”) (α= .93), *Understanding and Friendliness* (e.g. “This teacher is willing to explain things to me again”) (α= .93) and *Controlling* (e.g. “This teacher demands that I listen to instructions”) (α=.96) all with an acceptable Cronbach's alpha value of over .70

(Fornell & Larcker, 1981). Likewise, the above scale has an overall Cronbach alpha of .96. The second part consisted of the 'Importance of Physical Education' (IPE) created and validated by Moreno, Coll, & Ruiz (2009). The scale is composed by 3 items (e.g. “I think the things I learn in physical education will be useful in my life”), with a general Cronbach's alpha of .87.

The Kaiser-Meyer-Olkin (KMO) and Bartlett's test of sphericity was used to determine the validity of this study. For the TCBQ and IPE scales, the KMO value is .93 and .94 respectively. The Bartlett's test of sphericity was significant for both scales (p=.001). Therefore, the sample is appropriate for analysis. All communities are above .54, as the minimum required is .40. Finally, all scales used a 7-point Likert response scale, with 1 meaning “strongly disagree” and 7 “strongly agree”.

Procedures

In order to conduct the present study, firstly, the director of the centre was contacted, to whom the project and the questionnaire that would later be completed by the students were presented. Once we had the consent of the school management team and the teachers evaluated, the informed consents were sent to the parents or legal guardians of the students, as they were all underage. Afterwards, the students were gathered for 15 minutes before the PE classes in the computer room and the questionnaire was passed, with a filling time of approximately 10 minutes. The students were informed at all times that the data collected would be anonymous and would be treated only for academic purposes. In addition, to avoid any bias in the responses, it was explained in detail that the teachers would not have access to the information individually. Furthermore, the teachers themselves were not in the classroom at the time of the online completion of the questionnaire. The LimeSurvey software was used to collect the questionnaire, which generates a database directly with the answers obtained.

Statistical analysis

Data processing was conducted using SPSS 23.0 software. We analysed the mean (M), standard deviation (SD), skewness (S) and kurtosis (K) of the dimensions of the Teacher Communication (TC) and Importance of Physical Education (IPE). In addition, in order to know the relationship between the variables analysed, Pearson’s correlations were calculated. With the aim of determining the effect of the perception of the teacher's communication in the classroom on the students' IPE, linear regressions were carried out.

RESULTS

Considering the results obtained in the present study, in Table 1 we can see the average assessments of the scales analysed and the dimensions that compose them: TC and IPE, in terms of means, standard deviation, skewness and kurtosis. The distribution of the TC scale has a normal distribution since the values of skewness and kurtosis are between -2 and 2, as well as the IPE scale.

Table 1 Descriptive statistics of Teacher Communication and Importance of Physical Education

	Mean (SD)	S	K
Teacher Communication	4.22 (1.19)	-.23	.17
1. Challenging	3.93 (1.47)	-.19	-.82
2. Encouragement and Praise	3.50 (1.49)	.20	-.75
3. Non-verbal Support	3.85 (1.64)	.07	-1.0
4. Understanding and Friendliness	4.84 (1.62)	-.64	-.54
5. Controlling	4.99 (1.27)	-.78	.43
Importance of Physical Education	4.56 (1.81)	-.44	-.89

Legend: S=Skewness; K=Kurtosis.

Considering the results obtained in the present research, it is observed that there is a significantly positive relationship between *Challenging* and IPE (r=.40; p≤.001) and between *Encouragement and Praise* and IPE (r=.38; p≤.001). In addition to the above, as reflected in Table 2, there is a significant relationship between *Non-verbal Support* and IPE (r=.32; p≤.001), *Understanding and Friendliness* and IPE (r=.39; p≤.001), and *Controlling* and IPE (r=.30; p≤.001).

Table 2 Correlation between Teacher Communication and Importance of Physical Education

	1	2	3	4	5	6
1. Challenging	1					
2. Encouragement and Praise	.67***	1				
3. Non-verbal Support	.57***	.74***	1			
4. Understanding and Friendliness	.60***	.63***	.69***	1		
5. Controlling	.41***	.24***	.28***	.38***	1	
6. Importance of Physical Education	.40***	.38***	.32***	.39***	.30***	1

Legend: *=p≤ .05; **=p≤ .01; ***=p≤.001.

Nevertheless, based on the results obtained in the regression of TCBQ on IPE, the model showed significant results (F=20.92; p≤.001). Considering the linear regression performed and the results obtained, we can highlight that the TC scale indicates an effect of 19.70% of the variance of the IPE (R=.47; R^2=.22; R^2adj=.20; p≤.001). The coefficients show that the *Understanding and Friendliness* dimension (β=.17; p<.05) is the most important factor in the model (see Table 3), followed by the *Controlling* dimension (β=.15; p<.05). Standardized coefficients have been considered in all the analyses.

Table 3 Teacher Communication regression on Importance of Physical Education

	R^2adj	β
	.20***	
Challenging		.14
Encouragement and Praise		.18
Non-verbal Support		.05
Understanding and Friendliness		.17*
Controlling		.15*

Legend: *= p≤.05; **=p≤.01; ***=p≤.001.

DISCUSSION

Communication

Human beings are immersed in a constant process of interaction with the environment (Güleç & Leylek, 2018), with communication being a necessary aspect in the process of production and distribution of information. Under this aspect, communication can be understood as an essential piece in human coexistence, capable of promoting the liberation of feelings and ideas that condition, to a great extent, interpersonal relationships, solidarity, cooperation, empathy, social cohesion and the possibility of understanding among people (Wiemann, 2011). Communication has also been understood as the means of spreading information between social and physical people by using a pre-established code of signs (Rizo García, 2007), being considered as one of the most basic conditions of every human in order to be integrated into society and to empathize with the rest of humans.

In any animated communication, words are accompanied by body and facial expressions, a certain body position, movement when transmitting, eye contact, etc. However, although they commonly go together, two main types of communication can be distinguished: (i) verbal communication highlighted by the use of words and (ii) non-verbal communication characterized by the use of facial expressions, movements and body postures, including the distance at which the communication is maintained, always emphasizing the absence of words.

According to Cabrera Cuevas (2003) there are five different types of communication in the classroom: (i) *affective communication*, which is based on a nearby and expressive language towards the students, emphasizing facial expressions such as smiling or paying attention; (ii) *flexible communication*, based on tolerance towards the students' role and their attitudes. Therefore, there will not be a defined line in the student's role; (iii) *authoritarian communication*, characterized by the imposition of a role by the teacher that provokes the consequent submission and passivity of the students; (iv) *conciliatory communication*, by creating a relationship in which empathy, understanding and conformity with the students stand out. Communication is the basis for making decisions and reaching agreements; and (v) *hierarchical communication*, in which the teacher establishes a role in which he or she is given social recognition.

On the other hand, She and Fisher (2000) developed and validated a questionnaire that measures explicitly five teacher types of communication according to student perceptions: (i) *Challenging*, style of communication where the faculty raise questions, activities, etc. that challenge students, giving them a central role; (ii) *Encouragement and Praise*, where the faculty stimulate students to give their opinion, and include it positively in the dynamics of the classes; (iii) *Non-verbal Support* based on gestures with the head, face, hands, or other parts of the body supporting the student's interventions; (iv) *Understanding and Friendliness*, where teachers transmit to students that they trust them, listening to them and being patient and keeping a close relationship with them; and (v) *Controlling*, where the faculty require students to do things, as they say, obeying them in the instructions they provide, reducing student autonomy.

One way or another, regardless of the theoretical model followed concerning the types of communication by the faculty, as stated in the introduction, teachers' communication processes have an impact on student motivation. Therefore, communication skills are a fundamental in a variety of areas, such as medical training programs (van der Vleuten, van den Eertwegh, & Giroldi, 2019) or in the field of education (Nasheeda, Abdullah, Krauss, &

Ahmed, 2019). Nevertheless, the forms of communication are changing, going from a primarily spoken language, face to face, towards the extended use of social media to communicate with other people. In the educational field, and specifically in PE, there are many studies that have already analysed the introduction and impact of new technologies in PA (Yildiz, Güzel, & Devrim Zerengök, 2019; Cabrera-Ramos, 2020; Díaz-Barahona, 2020). Nevertheless, where is the analysis and study of the oral communication teacher-student developed during classes? There is a research gap in this regard.

Physical Education as a space to develop healthy living habits

Generally, PE is a mandatory subject for a few years in education, so it is a unique scenario to promote healthy living habits and encourage interest in extracurricular PA. The importance students give to PE is closely related to interest in extracurricular PA (Baena-Extremera, Gómez-López, Granero-Gallegos, & Abraldes, 2014) and to the creation and establishment of sports habits (Kilpatrick, Hebert, & Jacobsen, 2002). Therefore, in this context, teachers have a responsibility to students not only within the classroom, but also in learning healthy habits.

Within the context of PE, one of the most important theories is the theory of self-determination by Ryan and Deci (2000). These authors distinguish motivation on different levels: intrinsic and extrinsic motivation, while lack of motivation is called amotivation or demotivation. If students are motivated by the teacher, they are likely to attach greater importance to PE and thereby improve their view of sports practice and sport in general. However, if there is no motivation from the teacher or the generated climate that the students perceive is not adequate, a negative attitude towards the subject can be created. In this sense, communication is a key aspect in the teacher-student relationship and in the climate generated in class; however, it has not been previously studied in relation to communication in the field of PE.

Motivation plays a key role in most activities, but it is even more prominent in the field of education and sport, as the commitment and level of involvement with the subject will be greater the higher the motivation of the students. Among the different types of motivation, in the educational field the intention is to achieve a high degree of intrinsic motivation, since various studies (Hein, Müür, & Koka, 2004; Slingerland & Borghouts, 2011; Moy, Renshaw, & Davids, 2016; Sierra-Díaz et al., 2019) have shown how this type of motivation has an important influence on the intentionality of extracurricular sports practice and the creation and consolidation of active and healthy lifestyles.

The subject of PE is a suitable curricular space to develop the motivation of the students towards the practice of sports. Even though PE classes differ in time and content from country to country and from region to region, as a whole they contribute to achieving minimum PE levels (Mayorga Vega, Martínez Baena, & Viciana, 2018). Nevertheless, the total time of the course is different from the time of motor commitment during these lessons, as the latter is significantly less. In any case, PE lessons should be considered as a valuable opportunity to learn about, and develop physical-sports practices that can facilitate the development of extracurricular PA, helping to create healthy physical habits which are fundamental for the development of health (Cho & Kim, 2019).

Given the influence that PE can have on the health of adolescents, the responsibility that PE teachers have is much larger than anyone could possibly think. The creation of motivating educational contexts, planning and developing different, innovative and

motivating tasks and establishing a close and trusting relationship between the teacher and his or her students are important factors for which the responsibility lies, to a large extent, with the PE teaching staff. Within the relationship between teachers and students, communication is a vital factor (Güleç & Leylek, 2018). In this sense, it is during the lessons that a relationship of trust can be efficiently established. In this way, PE teachers become a key agent in promoting active and healthy lifestyles (Sierra-Díaz et al., 2019). Therefore, it is important to be aware of the impact of motivation PE classes on the promotion of PA at early ages (Wallhead et al., 2014).

The role of teacher communication in the classroom

In all fields of action, communication is important. Nevertheless, in the educational field in general, and in schools in particular, communication processes are carried out more intensively, and it is essential to acquire communication skills among people (Cañabate, Martínez, Rodríguez, & Colomer, 2018). Teachers must not only teach their students, but also be responsible for establishing effective communication with them, solving problems and transmitting confidence (Güleç & Leylek, 2018).

Several authors have explained the significance of effective communication between teacher and student, as it will help to establish and maintain a more satisfactory and sincere relationship (Kaya, Ozay, & Sezek, 2008). If students are able to express themselves openly and perceive a feeling of understanding on the part of the teacher, a positive attitude and a positive relationship will be created in which both will be able to express themselves more satisfactorily and with more positive results (Khine & Fisher, 2003). Furthermore, Moreno-Murcia, Huéscar, Peco, Alarcón, & Cervelló (2013), highlight the importance of teacher-student feedback in ensuring that the teaching-learning process is effective. Such feedback is understood as the feedback that needs to be provided to students, enabling them to learn as much as possible from what they are being assessed for (Lambrechts, Mulà, Ceulemans, Molderez, & Gaeremynck, 2013). In this regard, teachers express what they know in such a way that it reaches their students through communication, just as the students themselves manifest what they have learned through language and communication, both oral and written (Rizo García, 2007).

According to Duta, Panisoara, and Panisoara (2015), human beings communicate information, ideas and expectations in different ways, in different contexts and with different people; therefore it is essential to focus attention on how we communicate. Effective and efficient communication between the teacher and student creates a connection between them. Thus, communication plays a key role in the creation and maintenance of a quality learning system (Eupena, 2012).

As we are aware, communication is a fundamental issue in all areas and at all ages, but even more so among Secondary Education students, since they are at a stage where the patterns of behaviour they develop will have a profound influence on later adult life. Therefore, it is important to know and study the surrounding social context in which the PE teacher is involved. In this sense, it is well known that the attitude of the PE teacher contributes directly to the sport practice of the students and in the dissemination of values (Jiménez, García, Santos-Rosa, Moreno, & Cervelló, 2010). Therefore, given the importance that PE teachers have in the conduct of adolescents, it is not surprising that the type of communication that is maintained by PE teachers with students is of major importance. Nevertheless, in spite of the fact that the lack of communication that takes place in

interpersonal relations is a serious problem that occurs in our society, the academic literature is scarce with regards to the analysis of the direct influence that the type of communication of PE teachers with their students has, along with its effects on their sports motivation.

The aim of this study is to know the effect of the teacher's communicational dimensions (challenging, encouragement and praise, non-verbal support, understanding and friendliness, and controlling) on the perception of the importance given to PE. According to the results obtained, the TCBQ has an effect of 19.7% on the student's perceived importance of PE. While so far studies such as the one conducted by Eupena (2012), which encompasses TCBQ within the scope of teacher effectiveness and is perceived as a key element in motivating students to learn, the results of this study are relevant from the point of view that through the communication styles of the PE faculty, it is possible to have an impact that goes beyond the scope of PE, and is closely related to increased extracurricular activity (Cabello, Moyano, & Tabernero, 2018). This, in turn, can have an impact on the generation of healthy lifestyle habits, as Moreno-Murcia et al. (2013) emphasize that student motivation in PE classes can be an important aspect in generating adherence to the physical-sports practice. Furthermore, PE faculty develop a relevant role towards students' motivational experiences, something that can be transposed to autonomous motivation in a leisure-time PA context (Sevil-Serrano, Aibar, Abós, Generelo, & García-González, 2020).

Regarding TCBQ styles, in this study, the *understanding and friendliness* dimension is the most important factor in the model. In the scale used, this dimension corresponds to the confidence that the teacher transmits to the students and the patience that generates a close relationship with them. Teachers who stimulate students and provide positive feedback create more autonomous and positive school contexts and organizational climates (Whilhelmsen, Sorensen, & Seippel, 2018). Thus, the results of this study, which show the significance of the type of communication carried out by PE teachers, are in accordance with the conclusions of the studies of Lindgren and associates (2019), and Abula and associates (2020), where the direct and indirect impact that PE teachers have on the development of healthy habits by students is highlighted. The PE teacher should be aware that they are primarily responsible for creating the subsequent experiences in their students. Therefore, the relationship that they have with them and the sensations that they generate will have, as a consequence, habitual sport practice. The results obtained, on the one hand, are coherent with what was exposed in the previous literature since understanding and friendliness would enter the factors that would lead to the importance of PE. The ability to understand the student and the patience demonstrated to improve the teacher-student relationship is a well-studied aspect of education and is closely related to the final results. Within them, the type of communication that the PE teacher makes is key as it encompasses all the above. Nevertheless, the type of communication expressed by the teaching staff, the climate generated by it must also be added, in which trust and respect must be the pillars of the relationship.

In addition, another important factor in IPE is the *controlling* dimension that corresponds to the monitoring and subsequent feedback generated by the teaching staff. This is in line with statements of Moreno-Murcia, Huéscar, Peco, Alarcón, & Cervelló (2013) and Lambrechts and associates (2013), who highlight the importance of feedback between teacher and student, allowing for maximum learning within the teaching-learning process. Nevertheless, the results obtained contrast with those of other studies such as the ones conducted by Lim and Wang (2009) and Aibar and associates (2015), where the results highlighted that teaching styles that favoured student autonomy were those that favoured

greater intrinsic motivation towards PE, as well as a positive influence on the practice of PA in leisure time. For this reason, the result obtained stands out because it does not follow what is reflected in previous studies in the academic literature. Furthermore, there is no significant relationship between the rest of the types of communication of the teachers analysed towards the importance of PE for students, something that also draws attention, as this is not a result that has been found in similar studies.

In any case, besides highlighting the importance of teachers' communication styles, we agree with what was stated in recent studies (van de Kop, van Kernebeek, Otten, Toussaint, & Verhoeff, 2019; Sevil-Serrano et al., 2020) which suggest strategies of interventions based on multicomponent PA programs. These initiatives that jointly involve not only PE but also other non-curricular areas and social agents (e.g., families and sports associations), going beyond the school, are promising approaches that can enhance the adolescents' PA levels.

CONCLUSIONS

The main results show that teacher-student communication has a high effect on the importance that students attach to EF, with *understanding and friendliness*, and *controlling* as the most important dimensions. These results contrast with other studies which highlight that teaching styles linked to the development of student autonomy are those that can foster a higher level of intrinsic motivation towards the promotion of PA. We did not find a justification for these results, so we recommend that future studies try to investigate this aspect specifically.

This study is not without limitations that should lead to careful consideration of the results. On the one hand, the sample is limited to a single private school with an English educational system in the Comunitat Valenciana Spanish region, something that may bias the results. Therefore, the results should not be generalised and we recommend carrying out similar studies with a larger sample, which also incorporates educational centres of different types (public, concerted and private), in order to ascertain whether the type of school may have any influence on the results.

On the other hand, it would be interesting to conduct qualitative studies, since most of the literature studying the effects of the type of communication on student importance towards PE and its influence on PA levels and other healthy habits is quantitative. Considering these limitations and future lines of research, this research highlights the importance of the type of communication that the PE teacher provides to motivate students towards PE classes.

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UTICAJ KOMUNIKACIJE NASTAVNIK-UČENIK NA ZNAČAJ FIZIČKOG VASPITANJA

Tokom adolescencije postoji značajan rizik od napuštanja sporta, povezanog sa sedentarizmom i prekomernom telesnom masom. Iz tog razloga, časovi fizičkog vaspitanja (PE) trebalo bi da budu prilika za približavanje fizičke aktivnosti i sporta školarcima, razvijanje i učvršćivanje zdravih životnih navika. S obzirom na značaj koji nastavne komunikacijski postupci mogu da imaju u motivaciji učenika i s obzirom na nedostatak specifičnih studija koje istražuju uticaj ovih procesa na motivaciju za bavljenje sportom, u kontekstu PE, cilj ove studije je da se utvrdi efekat nastavnikovih komunikacionih dimenzija (izazivanje, podsticanje i pohvala, neverbalna podrška, razumevanje i druželjubivost, i kontrola) na percepciju značaja koji se daje PE. Uzorak je sačinjavalo ukupno 203 učenika PE uzrasta između 10 i 16 godina. Analizirane su srednja vrednost (M), standardna devijacija (SD), skjunis (S) i kurtosis (K) dimenzija komunikacije nastavnika (TC) i značaj fizičkog vaspitanja (IPE). S ciljem utvrđivanja povezanosti između analiziranih varijabli, primenjena je Pearsonova korelacija, dok je sa ciljem utvrđivanja uticaja TC u učionici na IPE učenika, korišćena je linearna regresija. U obradi podataka korišćen je softver SPSS 23.0. Rezultati pokazuju da TC ima efekat od 19.7% na IPE. Razumevanje i druželjubivost i dimenzija upravljanja su sa najvišim standardizovanim koeficijentom regresije u percepciji učenika o IPE.

Ključne reči: *veštine komunikacije, nastavnici, značaj fizičkog vaspitanja*.

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Research article

PEDAGOGICAL, COGNITIVE AND METHODOLOGICAL ASPECTS OF DIGITALISATION IN PHYSICAL EDUCATION

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Abstract. *The implementation of digital education technology into the school subject of physical education (PE) has become a challenging trend of contemporary pedagogy. This paper emphasises the importance of the pedagogical, cognitive and methodological aspects of digitalisation in PE. The research presented examined the attitudes of PE teachers in primary and secondary schools towards digitalisation in PE. The research has three goals: 1. Theoretical-the review of all the international and national sources relevant for the perception of the theoretical aspects of introducing digitalisation into physical education teaching; 2. Cognitive-the study of PE teachers' attitudes towards digitalisation in PE as a school subject; 3. Applicable-a contribution to raising awareness about the importance of PE improvement. The methods used in the empirical research were the descriptive method, the survey and scaling technique with a questionnaire as the instrument and the assessment Likert-type scale (DOUF/DEIP). The questionnaire comprised of four closed-ended questions and the scale containing 40 items. The sample included 126 PE teachers from Serbia. The obtained results were calculated by the SPSS software version 24, used for the statistical data processing. The following statistical parameters for displaying results were used: frequency (f), percentage (%), arithmetic mean (M), standard deviation (SD), Pearson's chi-squared test ($\chi 2$), the t-test and ANOVA F-test. The research results show that PE teaching is undergoing digitalisation and that teachers have positive attitudes towards digital competences, technologies and the connection between digital education and quality of teaching, schoolchildren's academic achievements and the teacher's role.*

Key words: *Physical Education, Digitalisation, Technology, Primary and Secondary School Teachers, Empirical Research*

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INTRODUCTION

Physical education (PE) is a school subject taught in the majority of primary and secondary schools all over the world. Its primary goals are the stimulation of children's growth, integral personality development, posture, motor skills, habits of regular physical exercise and playing various sports, as well as schoolchildren's positive attitudes towards PE, exercise, sports and healthy lifestyles (Kretschmann, 2010; Džinović & Martinović, 2018; Ristić, 2018a; Višnjić & Marković, 2018). PE used to be one of the most favourite school subjects, yet nowadays, it is rarely the case. Namely, schoolchildren have developed the habit of skipping PE classes recently, which is reflected in a new sedentary lifestyle (Dobraš, Dragosavljević, Vučković, Gadžić, & Lepir, 2013). Children and adolescents frequently suffer from various health issues, such as obesity, physical inactivity and cardiovascular diseases (Gordon-Larsen, McMurray, & Popkin, 2000; Goran & Reynolds, 2005; Lin, Mamykina, Lindtner, Delajoux, & Strub, 2006; Džinović & Martinović, 2018). Also, a growing number of adolescents with foot disorders (Mihajlović, Smajić, & Sente, 2010) and posture problems have been reported, which consequently results in serious spine conditions. Therefore, insufficient motor and physical activity affects the quality of PE classes.

The children and adolescents of today belong to a digital generation. Their growth and upbringing are unavoidably influenced by the omnipresent technology of the contemporary world. Modern technologies have an impact on children's cognitive, perceptive and sensorimotor abilities (Mangen, 2010), whose interaction yields experiences significant for creating their own view of the world and their further personality development, skill building for problem solving, creative thinking and emotional well-being (Baltazarević & Baltazarević, 2019). The introduction of innovations and technologies into the education system has thus become a necessity and challenge for contemporary pedagogical science. The possibilities for introducing information technologies into school subjects are enormous since they permeate every segment of the education system and facilitate cooperation with the agents outside of it (Sandeep, 2011). As regards PE, Dobraš et al. (2013: 24) state that teaching materials are mainly incompatible with students' needs, which affects their motivation for PE classes. The task of pedagogy is to contribute to the enhancement of PE teaching and of schoolchildren's physical activity and general health. Digital education in PE appears to be an appropriate solution accorded with the trends of contemporary pedagogy.

This research aimed at examining PE teachers' attitudes towards digital education in PE classes concerning the following research tasks: digital competences and digital education in PE teaching, technologies used in PE classes, the connection between digital education and the quality of teaching, students' achievements and the teacher's role in PE teaching.

METHODS

Technological advancements have permeated every sphere of contemporary life. Belonging to social sciences, pedagogy has readily accepted the challenging task of introducing technologies into education and teaching. Teaching has evidently altered its framework owing to technologies applied in planning, realisation and evaluation of teaching-learning practices. Technology and digital devices have become an integral part of contemporary education, besides teachers and students. The aspect of digitalisation is

particularly evident in teaching the school subject of PE since it differs from other school subjects in many ways. PE classes are characterised by teachers and students being very active, involved in creating and maintaining healthy habits, positive attitudes towards sport, working-out, exercise and lifestyle in general. Their flexibility, dynamics and uniqueness make them suitable for the application of technologies with the purpose of the further advancement of teachers' competences, students' fitness and physical activity, as well as the improvement of teaching itself.

Therefore, the question is: *Is the school subject physical education undergoing digitalistaion?* The objective of this research was to examine primary and secondary school PE teachers' attitudes towards digital education of this school subject. The research goal and tasks were based on the study of teachers' attitudes towards digital competences, digital education and technologies that could be used in PE classes, as well as on determining the link between digital education and the quality of teaching, students' achievements and the teacher's role in PE teaching.

The research largely contributed to the comprehension of the importance of this issue and awareness of further improvement of PE teaching and students' and teachers' roles in teaching-learning practices accomplished by the use of technologies and digital education. The theoretical section of this paper analyses various theoretical, pedagogical, cognitive and methodological aspects of digitalisation and digital education in PE teaching by means of the method of theoretical analysis. The method used in the empirical section of the paper was the descriptive method. PE teachers' attitudes towards digital education in PE teaching were received by means of a survey and scaling techniques and the use of the questionnaire and the Likert-type assessment scale, named Digital education in physical education (DOUF/*DEIP*). The questionnaire comprised four close-ended questions, and the Likert scale contained 40 items, equally distributed in four subscales in accordance with the aforementioned research tasks. The examination of the metric characteristics of the instrument by means of Cronbach's Alpha coefficient (Cronbach's Alpha=0.961) proved that the constructed instrument was reliable, i.e., that the elements were consistent and valid for the subject matter of the research.

The research was conducted in central and southern Serbia in May and June 2020. The respondents were granted confidentiality regarding their responses in the questionnaire. Due to the current COVID-19 epidemiological situation, the research was conducted in two ways: by using the application Google questionnaire online and in the field, respecting all the measures prescribed for the prevention of the spread of the coronavirus disease. The research sample was not based on the probability sampling technique, i.e. it was not selected using a random selection. The selection of the respondents was governed by the teachers' decision and desire to participate in the research. The sample comprised 126 PE teachers. As regards the gender, there were 64 male teachers (50.8%) and 62 female teachers (49.2%), which proved an almost even number of teachers of both genders teaching this school subject. Regarding teaching experience, there were 46 teachers with 0 to 10 years' teaching experience (36.5%), 53 teachers who had been teaching for 11 to 20 years (42.1%) and 27 teachers with the teaching experience longer than 20 years (21.4%). Concerning the type of school, there were 73 (57.9%) primary school PE teachers and 53 (42.1%) secondary school PE teachers.

The obtained results were calculated by the SPSS software version 24, used for the statistical data processing. The following statistical parameters for displaying results were used: frequency (f), percentage (%), arithmetic mean (M), standard deviation (SD), Pearson's chi-squared test ($\chi 2$), the t-test and ANOVA F-test.

RESULTS

The first part of the instrument was a questionnaire containing four close-ended questions. The questionnaire examined the first research task related to digital competences and digital education in PE teaching. Possible statistically significant differences in the frequencies of the respondents' replies to the posed questions were examined by Pearson's chi-squared test. It should be emphasised that the cross reference of the independent variable gender with the dependent variables of the first research task did not show statistically significant differences in the frequencies of the responses. The conclusion is that PE teachers of both genders provided homogenous responses to the question presented in *Table 1*. This segment of statistical data processing was not shown in the table due to the lack of statistically significant difference in the frequencies of the respondents' responses.

Table 1 Differences in the obtained responses about digital competences regarding teaching experience

			Teaching experience (years)			Total:
			0-10	11-20	Over 20	
Digital competences involve:	Browsing the Internet	f	12	4	11	27
		%	9.5	3.2	8.7	21.4
	Use of information and communication technologies	f	34	48	15	97
		%	27	38.1	11.9	77.0
	Use of social media	f	0	1	1	2
		%	0	0.8	0.8	1.6
Total:		f	46	53	27	126
		%	36.5	42.1	21.4	100

χ^2=14.39; df=4; p=0.01; C=0.24

Table 1 displays a statistically significant difference in the respondents' replies to the question about digital competences regarding their teaching experience. The statistically significant difference was $p<0.05$ ($p=0.01$). The majority of the respondents (77.0%) thought that digital competences involved the use of information and communication technologies, whereas a smaller number of them (21.4%) indicated that digital competences involved browsing the Internet. A negligible number of the respondents (1.6%) emphasised the use of social media as a digital competence. The conclusion is that the majority of teachers understood the fundamental concept of digital competences, which considerably contributes to a positive attitude towards digitalisation of PE teaching.

The distribution of the responses to the second question from the questionnaire, *Can you assess the level of your digital competence?* was the following: more than half of the respondents (76.2%) said that they had enough skills, knowledge and experience for using technologies, while a small number of them (23.8%) gave contrary answers. *Table 2* shows a statistically significant difference in the respondents' replies regarding their teaching experience. This statistically significant difference was estimated as $p<0.05$

(p=0.00). The obtained results prove that more than half of the respondents believed they possessed a sufficient number of competences, crucial for the introduction and implementation of the idea of digital education into PE teaching. This further proves that PE teachers are qualified for the application of technologies with the purpose of accomplishing better teaching outcomes.

Table 2 Differences in the obtained responses about digital competence self-assessment regarding teaching experience

			Teaching experience (years)			Total:
			0-10	11-20	Over 20	
Can you assess the level of your digital competence?	I think that I have enough knowledge, skills and experience for using technologies	f	46	37	13	96
		%	36.5	29.4	10.3	76.2
	I do not think that I have enough knowledge, skills and experience for using technologies	f	0	16	14	30
		%	0.0	12.7	11.1	23.8
Total:		f	46	53	27	126
		%	36.5	42.1	21.4	100

χ^2=27.27; df=2; p=0.00; C=0.47

Besides the aforementioned statistical significance, a statistically significant difference was evident in the frequency of the responses to the posed question regarding the school in which the respondents were employed as PE teachers (χ^2=3.83; df=1; *p=0.05* (p≤0.05); C=0.17), more precisely whether they taught PE in primary or in secondary school. Therefore, the conclusion is that differences were detected in the respondents' replies to the question about digital competence self-assessment in relation to their teaching experience and the school in which they taught.

What follows are the responses to the question about the concept of digital education:

Table 3 Differences in the obtained responses about the concept of digital education regarding the school facilities

			School		Total:
			Primary school	Secondary school	
The concept of digital education is:	Computer- and Internet-assisted learning	f	33	6	39
		%	26.2	4.8	31.0
	Technical equipment and devices in schools	f	2	0	2
		%	1.6	0.0	1.6
	Academic achievements accomplished by applying technology	f	38	47	85
		%	30.2	37.3	67.5
Total:		f	73	53	126
		%	57.9	42.1	100

χ^2=18.95; df=2; p=0.00; C=0.39

A statistically significant difference was determined in the responses about the concept of digital education regarding the school in which the respondents were employed as teachers. The difference was estimated as p<0.05 (p=0.00). Namely, *Table 3*

shows that more than half of the respondents (67.5%) acknowledged that digital education meant the accomplishment of academic achievements by the application of technology. A smaller number of the respondents (31.0%) stated that computer- and Internet-assisted learning represented the concept of digital education, while the smallest number of the respondents (1.6%) equated the concept of digital education with technical equipment and devices in schools. It can be concluded that the majority of the PE teachers who participated in this research understood the concept of digital education correctly, which is a significant contribution to the further improvement of PE teaching. No differences were detected in the responses regarding the variable teaching experience, which implied that these responses could be considered homogenous concerning this independent variable.

The last question in the questionnaire was *Why do you think it is necessary to introduce technology into physical education classes?*. The responses are presented in the table.

Table 4 Differences in the obtained responses about the necessity of introducing technology into physical education regarding the school facilities

			School		Total:
			Primary school	Secondary school	
Why do you think it is necessary to introduce technology into physical education classes?	Students use technology in everyday life, so it should be used in physical education classes as well.	f	4	1	5
		%	3.2	0.8	4.0
	Technology is used in all school subjects, so physical education should not differ.	f	48	14	62
		%	38.1	11.1	49.2
	Physical education curricula allow teachers to be creative, which can be accomplished by the application of technology.	f	21	38	59
		%	16.7	30.2	46.8
Total:		f	73	53	126
		%	57.9	42.1	100

χ^2=22.74; df= 2; p=0.00; C=0.43

A statistically significant difference in the responses about the necessity of introducing technology into PE classes was determined regarding the school in which the respondents were employed as teachers. The difference was estimated as $p<0.05$ ($p=0.00$). *Table 4* displays that almost half of the respondents (49.2%) stated that the reason for introducing technology into PE classes was conditioned by the fact that technology was applied in all school subjects and that PE should not be treated differently. Less than half of the respondents (46.8%) replied that PE curricula allowed teachers to be creative, which could most easily be accomplished by the application of technology, whereas the smallest number of respondents (4.0%) thought that technology should be introduced into physical education classes because of students' everyday use and knowledge of modern technologies.

A statistically significant difference was detected in the frequency of the obtained responses to the posed question regarding the independent variable teaching experience (χ^2=11.15; df=4; *p=0.03* ($p<0.05$); C=0.21). Therefore, the obtained results prove that the

respondents' replies to the question about the reasons for introducing technology into PE classes differed regarding the dependent research variables.

Table 5 Differences in the obtained responses about digitalisation of physical education teaching regarding gender

	Gender	N	M	SD	t	df	p
Technologies used in physical education teaching	Male	64	32.78	5.99	-3.86	121	0.00
	Female	62	36.55	4.94			
Connection between digital education and quality of physical education teaching	Male	64	41.03	5.00	-7.25	122	0.00
	Female	62	46.98	4.20			
Connection between digital education and students' achievements in physical education	Male	64	36.03	6.33	-5.54	124	0.00
	Female	62	42.90	7.56			
Connection between digital education and the teacher's role in physical education	Male	64	36.58	6.74	-5.98	124	0.00
	Female	62	43.81	6.82			

Table 5 displays the results obtained from the responses to the research questions regarding the independent variable of gender. The data were statistically processed and a statistically significant difference in the responses was determined by means of the t-test. Regarding the first research task related to the respondents' attitudes towards the technology used in PE teaching, the female respondents (M=36.55) expressed greater preference than the male teachers (M=32.78). Namely, the female PE teachers used video cameras, LCD projectors, MP3 players, mobile phones, computers, the Internet and other technological devices and media during PE classes more frequently than their male counterparts. Based on the value of the statistical significance (p=0.00) and in accordance with $p<0.05$, a statistically significant difference was determined in the obtained responses regarding gender. Statistically significant values of p=0.00 ($p<0.05$) were evident for the responses to the items in the remaining three research questions regarding the respondents' gender. As regards the connection between digital education and the quality of PE teaching, the female respondents (M=46.98) expressed more positive attitudes and valued the connection between digital education and the quality of teaching more than the male respondents. Also, the female PE teachers (M=42.90) had more positive attitudes towards the connection between digital education and students' achievements than their male counterparts (M=36.03). A statistically significant difference was detected in the responses about the connection between digital education and the teacher's role. The female respondents (M=43.81) assessed this connection more positively than the male PE teachers. It is concluded that there were statistically significant differences in the obtained responses to the four research tasks regarding the respondents' gender and that female respondents expressed more positive attitudes than their male counterparts.

Table 6 Differences in the obtained responses about digitalisation of physical education teaching regarding the school facilities

	School	N	M	SD	t	df	p
Technologies used in physical education teaching	Primary school	73	34.80	6.26	-0.56	122	0.58
	Secondary school	53	34.96	5.13			
Connection between digital education and quality of physical education teaching	Primary school	73	42.80	6.03	-3.01	124	0.00
	Secondary school	53	45.55	4.19			
Connection between digital education and students' achievements in physical education	Primary school	73	38.33	8.86	-2.00	122	0.05
	Secondary school	53	40.91	5.62			
Connection between digital education and the teacher's role in physical education	Primary school	73	39.27	7.96	-1.49	124	0.13
	Secondary school	53	41.32	7.15			

One of the independent research variables was the school in which the respondents were employed as PE teachers. Using the statistical parameter t-test, a statistically significant difference was determined in the responses regarding this independent variable. *Table 6* shows that the responses about the technologies used in PE teaching did not differ significantly regarding the school in which the teachers were employed, i.e. the responses provided by primary and secondary school teachers were homogenous. Both primary and secondary school PE teachers responded in the same manner concerning the technological devices that could be used in PE teaching ($p>0.05$; $p=0.58$). The responses obtained from secondary school teachers ($M=45.55$) differed from those provided by primary school PE teachers ($M=42.80$) regarding the second question related to the connection between digital education and the quality of PE teaching. The difference was estimated as statistically significant $p<0.05$ ($p=0.00$). Secondary school teachers expressed more positive attitudes towards the connection between digital education and the quality of PE teaching than primary school teachers. These attitudes reflected the idea that digital education could enrich, modernise and improve this school subject and that it could be applied in planning, realising and evaluating PE teaching with the purpose of accomplishing all educational and teaching goals established by school curricula. Also, there was a statistically significant difference in the respondents' attitudes towards the connection between digital education and students' achievements in PE. Namely, secondary school teachers ($M=40.91$) expressed more positive attitudes than primary school PE teachers ($M=38.33$), which means that secondary school teachers could better perceive and understand the concept of digital education as crucial in improving students' achievements, motivation and interests in PE. The difference was determined as statistically significant $p\leq0.05$ ($p=0.05$). Finally, the responses of both secondary and primary school teachers were homogenous regarding the connection between digital education and the teacher's role in PE teaching. The obtained responses did not differ

significantly (p>0.05; p=0.13) regardless of the school in which the respondents were employed as PE teachers.

The Anova F test was used to determine statistically significant differences in the responses regarding teaching experience.

Table 7 Differences in the obtained responses about digitalisation of physical education teaching regarding teaching experience

	Teaching experience	N	M	SD	F	df	p
Technologies used in physical education teaching	0-10	46	36.41	5.67	11.03	2	0.00
	11-20	53	35.22	5.04			
	Over 20	27	30.44	5.50			
Connection between digital education and quality of physical education teaching	0-10	46	44.61	3.26	0.95	2	0.39
	11-20	53	44.00	7.05			
	Over 20	27	42.78	4.98			
Connection between digital education and students' achievements in physical education	0-10	46	41.00	4.83	10.80	2	0.00
	11-20	53	40.93	8.07			
	Over 20	27	33.70	8.65			
Connection between digital education and the teacher's role in physical education	0-10	46	41.39	6.08	6.81	2	0.00
	11-20	53	41.40	8.26			
	Over 20	27	35.52	7.36			

The responses obtained from the teachers with 0 to 10 years of teaching experience (M=36.41) showed that they favoured the use of technologies in PE classes in comparison to their more experienced colleagues. The difference in the responses was statistically significant p<0.05 (p=0.00). This result was expected owing to the fact that younger PE teachers were more qualified for the application of technologies in teaching because of their digital competences and everyday use of technology. The respondents' attitudes towards the connection between digital education and the quality of PE teaching did not differ significantly (p>0.05; p=0.39) regarding their teaching experience. From the point of view of statistics, the responses were analogous and equivalent. On the other hand, the data presented in *Table 7* show that there was a statistically significant difference in the respondents' attitudes towards the connection between digital education and students' achievements in PE regarding the independent variable of teaching experience. This statistically significant difference was evaluated as p<0.05 (p=0.00). Namely, the PE teachers with 0 to 10 years of teaching experience (M=41.00) expressed more positive attitudes than their more experienced colleagues, and they thought that the use of digital education and technologies could significantly contribute to students' academic achievements in PE. Since this group of teachers used technology in their classes more than their more experienced colleagues, it is logical that they ascribed their students' academic achievements to the application of technology in teaching. The displayed results also show that statistically significant differences were detected in the responses related to the last research task – the connection between digital education and the teacher's role in PE teaching. It is interesting that the PE teachers with 11 to 20 years of teaching experience (M=41.40) indicated that the use of technology in PE teaching had a positive impact on their self-confidence, motivation, reputation, cooperation with colleagues and consequently on their role in PE teaching. It is assumed that teachers with 11 to 20 years of teaching

experience displayed considerable understanding of the importance of technology and its use in teaching aimed at their own personal advancement and improvement as teachers, which is the reason why they provided the most positive responses compared to the responses of their less experienced and more experienced colleagues.

DISCUSSION

Digital education in PE presupposes the introduction of technologies into PE classes with the purpose of accomplishing the goals established by school curricula. The relevant sources state various factors that support digitalisation of PE teaching. Namely, Robinson (2011) emphasises that the omnipresent technology pervades every aspect of PE as a school subject. Consequently, it can easily be included into the framework of education. The introduction of technologies into PE classes does not reduce schoolchildren's physical activity but reveals new ways in which to become more active and raises their awareness about the importance of PE and general health. Moreover, information and communication technologies have already become an integral part of numerous school subject programmes. Digital technologies facilitate planning, programming, realisation and evaluation of teaching and are extremely beneficial for teachers (Ristić, 2018a). PE is a school subject that allows for the teacher's creativity in devising their classes to suit their students' needs (Višnjić & Marković, 2018). Therefore, PE represents a fruitful ground for the use and further development of technologies and digital education.

There is a number of various technologies, media and multimedia that can be used with great success in PE classes. Besides the radio, the oldest and the most widely spread technical device is certainly the television. Although it belongs to the group of *obsolete technologies,* the television is used in schools in order to show certain educational programmes. Then, there are the video recorder and video cameras that record schoolchildren's moves, facilitate the study of certain sports techniques and have a very positive effect on young people's self-reflection and self-introspection (Calandra, Gurvitch, & Lund, 2008; Baert, 2011; Casey & Jones, 2011; Semiz & Levent Ince, 2012; Bodsworth & Goodyear, 2017). The LCD projector displays recorded materials by connecting the projector to the television set, video camera or video recorder (Kretschmann, 2010). The use of video cameras and video recorders provides feedback that mostly influences the acquisition of motor skills, which is the fundamental task of PE (Banville & Polifko, 2009). Besides the aforementioned technologies, pedometers and heart rate monitors are unavoidable (Baert, 2011; Robinson, 2011; Semiz & Levent Ince, 2012; Bodsworth & Goodyear, 2017; Casey, Goodyear, & Armour, 2017; Ristić, 2018a; Pang, Varea, Cavallin, & Cupac, 2019). The pedometer is an instrument that measures the number of one's steps during a period of time, which is one of the indicators of the level of students' physical activity. On the other hand, heart rate monitors measure and display one's heart rate in real time and during physical exercise, which indicates one's physical fitness (Kretschmann, 2010; Baert, 2011).

Audio devices prove to be very useful in PE classes, particularly the MP3 player (Semiz & Levent Ince, 2012). Certain dances and dance moves accompanied by recognisable music are also studied in PE. MP3 players play the required songs and music, which enables learning of necessary dance moves in the most natural way (Kretschmann, 2010).

The greatest of all technological achievements of human intellect, the computer, is most widely used in teaching almost all of school subjects. This is further proved by the fact that only few classrooms are not equipped with computers. A further technological advancement has generated the laptop, a small, portable personal computer that can be also put to educational use. Personal computers can be used in various ways in PE classes. The computer can serve as the digital audio and video recorder that shows the materials recorded on compact disks (Casey & Jones, 2011) or USB flash drives. The Internet has transformed the personal computer into a technology of limitless possibilities. It allows access to certain sites, web platforms and educational software related to PE. Additionally, teachers and students browse websites in search of data and information regarding the importance of physical activity, fitness programmes, sports, diets and promotion of healthy lifestyles. They share advice by email and are thus constantly connected and active outside school gyms (Gibbone, Rukavina, & Silverman, 2010; Goran & Reynolds, 2005). Kretschmann (2010) deliberates that educational software contains videos that display specific sports techniques, tactics and even the games played by professional athletes, which can all enhance PE teaching. The power of social media is not to be overlooked (Pang et al., 2019) since they are used to distribute PE teaching materials , maintain communication, and monitor students' and teachers' achievements in physical activities.

As it has already been mentioned, the children of today are digital natives. This is illustrated by the fact that life is unimaginable without mobile phones and technologies. Every segment of contemporary life is imbued with mobile technology, which justifies its application in PE. Numerous authors have indicated that the mobile phone represents yet another technological device beneficial for PE teaching (Kretschmann, 2010; Robinson, 2011; Semiz & Levent Ince, 2012; Bodsworth & Goodyear, 2017; Ristić, 2018a; Pang et al., 2019). Mobile phones, either with the android or iOS operative system (iPhone), allow downloading of mobile applications that are used for the visual presentations of certain sports games, appropriate training, step measuring, health promotion, healthy dietary habits and physical fitness. The following are some of the most popular free apps: Nike Training Club, Samsung Health, Fitonomy, Adidas Training by Runtastic, RunKeeper, Workout Trainer, Beep Test, Google Fitness, Home Workout Without Equipment, Physical Education, Pedometer, Heart Rate Plus, Step Counter, 30-Day Fitness Challenge, Arm Workout, Body Editor, Infinity Fit, Water Reminder and others. Although these apps are not directly related to teaching materials, they make PE classes more modern, flexible and dynamic. Similar to personal computers, mobile phones allow access to YouTube, which is teeming with educational videos that assist PE teachers in designing creative teaching materials to be taught in school gyms, sports fields or schoolyards. PE teachers use other sites as well, such as the TubeChop (selecting particular parts of video clips that are useful for classes of PE) and the Posterous (posting personal video clips in order to enhance the quality of PE teaching). Robinson (2011) states that mobile phones can assist in digitalisation of PE in a number of ways. Calendars and clocks are accessed by mobile phones, which facilitates the arrangement of training sessions during classes. They are equipped with a practical video camera used for recording various materials that are beneficial for students and their motivation for physical activity. Mobile phones download and reproduce audio materials to accompany physical exercise related to games, dancing practice, training or working-out. Particularly

interesting are the GPS and QR codes, which stimulate students to compete in the number of completed tasks, exploration of nature and simultaneous physical exercise.

Tablets and iPad devices have proven very useful in PE classes. They are mainly used for playing video games, which dominate children's and adolescents' free time. However, video games can be appropriated for PE classes just like other technological innovations (Lin et al., 2006; Papastergiou, 2009; Gibbone et al., 2010; Mangen, 2010; Staiano & Calvert, 2011; Semiz & Levent Ince, 2012; Bodsworth & Goodyear, 2017; Rajić & Tasevska, 2019). They require a constant sensorimotor activity on the part of schoolchildren and thus have an effect on their behaviour (Chumbley & Griffiths, 2006). They have to be used in PE classes cleverly. One of the versions of video games are sports games that simulate particular sports and allow students to participate in athletic exercise and activities (Baert, 2011). Therefore, they can be used as a means of instruction aimed at students' better understanding and learning the rules of the games presented. Also, electronic games create a desire among students to accomplish a goal (Papastergiou, 2009). On the other hand, more frequent are the games known as *exergames*, which are actually a combination of a game and physical exercise and consequently beneficial for students' health, coordination, cognition, feedback, concentration, motivation and academic achievement (Baert, 2011; Staiano & Calvert, 2011; Maillot, Perrot, & Hartley, 2012). The following are some of the popular games combined with physical exercise: Dance Dance Revolution, How Fit are Wii (Papastergiou, 2009; Robinson, 2011), Fish'n'Steps, Tagaboo (Lin et al., 2006), etc. The PE teacher should observe the importance of video games for their students and create teaching materials accordingly. This will result in schoolchildrens' better academic achievement and comprehension of the importance of PE.

The introduction of digitalisation into PE depends on the teacher's digital and information competences. Digital competences are defined as one's competences to use information and communication technologies at work, in personal and social life and everyday communication in a secure and critical manner (Ristić & Blagdanić, 2017: 3). All teaching activities that are supported by information technologies demand that teachers be digitally qualified and possess the knowledge and skills acquired by education and professional training. According to Ristić (2018a: 49; 2018b) the teachers' education and training for the application of information and communication technologies in teaching comprises four phases: 1. Detection of the digital technologies' potential in teaching; 2. Learning how to use digital technologies; 3. Understanding where and when to use digital technologies; 4. Specialising in the use of digital technologies depending on the school subject taught. Regarding physical education, the teachers' and students' digital technologies are an integral part of contemporary teaching and should be promoted in PE (Vogt, Rehlinghaus, & Klein, 2019).

Research in the field has shown that the use of technologies in Serbian schools does not only depend on technical conditions and teachers' competences, but also on their enthusiasm and motivation to teach (Ristić, 2018b), as well as their self-confidence (Semiz & Levent Ince, 2012). The most important task of PE is to prepare schoolchildren for a continuous and lifelong physical activity. Having the greatest influence on students (Casey et al., 2017), the PE teacher is expected to provide a teaching environment suited to their students' internal motivation (Koka & Hein, 2003; Hans & Crasta, 2019) and cooperation that will breed success and overcome obstacles. Numerous authors (Ntoumanis, 2001; Standage, Duda, & Ntoumanis, 2003; Ntoumanis & Standage, 2009) believe that students' motivation for PE represents a particular issue related to the contemporary trend

of hedonistic and sedentary lifestyles. This issue may be resolved by the introduction of technologies into PE, which provide the feedback that stimulates students' physical efforts, desire and endeavours. This further proves that digital education in PE is indispensable in contemporary teaching. PE curricula are enriched by coordinating the already established academic achievements with the level of attained digital competences (Kretschmann, 2010). Digitalisation may be implemented into planning, programming, realisation and evaluation of PE teaching. The value of the applied technology is determined by its benefits for curricular and the majority of extracurricular activities (Ristić & Blagdanić, 2017), which are more flexible and more suited to students' interests and which make this school subject specific. Understood as the means of further promotion of health, physical exercise and training, technology cannot have any negative effects on schoolchildren's and adolescents' present physical fitness and activity. Educational data can be accessed at any place and at any time via mobile phones, applications and educational software (Lin et al., 2006). Moreover, motivational video materials and the use of video cameras, personal computers or tablets can significantly improve students' health and raise their awareness of their personal growth, the importance of healthy lifestyles and continuous physical activity. Numerous sports video games positively influence students' attitudes towards a particular sports game or a professional athlete, which further motivates them to play sports, to do athletics or gymnastics. PE classes taught in school gyms become more innovative and interesting, stimulating students' inner and outer motives for a better performance. Therefore, the quality of PE teaching is higher and accorded with contemporary trends in education.

Contemporary education is characterised by the use of modern technologies and implementation of digital education. Also, an important task is to determine whether PE teaching is undergoing digitalisation and how this aspect is connected to the fundamental elements of teaching. It is very important to examine PE teachers' attitudes towards this educational phenomenon. The methodology used in this research is based on these theoretical postulates and applied in the empirical study of the technologisation of teaching-learning practices.

PE is a mandatory school subject whose particularities differentiate it from other school subjects. The goal of PE as a school subject is to stimulate schoolchildren's growth and development, adequate posture, motor abilities and skills, as well as to encourage their positive attitudes towards PE, physical exercise, sports and healthy lifestyle (Kretschmann, 2010; Džinović & Martinović, 2018). The introduction of digital education into PE teaching is crucial for the accomplishment of the primary goals of this school subject. The introduction of technologies and the concept of digital education into PE teaching contributes to the coordination between teaching and daily activities since technologies have become common in all spheres of life (Robinson, 2011). Digital and information and communication technologies facilitate planning, programming, realising and evaluating of teaching since teachers are offered creative solutions to be applied during physical education classes in school gyms (Ristić, 2018a; Višnjić & Marković, 2018). This can be accomplished if PE teachers possess sufficient digital competences regarding the use of information and communication technologies, which have become essential in contemporary education (Vogt et al., 2019). Research in this field (Kretschmann, 2015) proves that the introduction of technologies into PE classes depends directly on the level of the teacher's digital and information literacy. Therefore, teachers' further

professional training should be based on acquiring digital competences and learning how to appropriately use technology as a powerful teaching tool.

Regarding other aspects of the concept of digital education in PE, certain studies (Perrota, 2013) discuss that the use of technology in teaching is particularly beneficial for teachers since it influences their self-confidence and the desire to use technology more frequently (Semiz & Levent Ince, 2012). The use of technology in all curricular and extracurricular activities confirms that contemporary education is appropriate and synchronised with current trends. Moreover, the introduction of technology into PE teaching contributes to students' greater academic achievements, their motivation and the improvement of the teaching-learning atmosphere (Casey & Jones, 2011). Also, some research (Yaman, 2008) proves that female teachers as well as younger teachers use technology in PE teaching more frequently than male teachers and more experienced teachers, which correlates with the results obtained in the research presented in this paper.

The mentioned research states that the use of technology and digital education are closely related to the quality of teaching, students' academic achievements and the teacher's role in PE. This proves that the issue of digital education in PE teaching is a scientifically based phenomenon, which is compatible with the findings of the empirical research presented.

CONCLUSION

The advantages of digital education in PE are numerous. Technical devices have become an integral part of teaching, occupying a central position in PE. One of the advantages of the introduction of digital education into PE teaching is its positive effect on all participants in the teaching-learning practice and on the better quality of teaching. The introduction of technology contributes primarily to the improvement and modernisation of PE teaching. This refers to the technological equipment to be installed in school gyms.

The results of this research prove that teachers properly understand the terms digital competence and digital education, and that they comprehend the reasons for the introduction of technology into PE teaching. Namely, more than half of the respondents (76.2%) stated that they possessed enough competences, knowledge and skills for the use of technologies and digital education in PE teaching, which is one of the most significant findings of this research. The obtained results illustrate that PE teachers are considerably qualified for the application of technological devices in teaching in order to complete the tasks prescribed by school curricula. The research also confirms statistically significant differences in the obtained responses regarding teaching experience and the school in which the respondents were employed as teachers ($p<0.05$), but not regarding the gender of the respondents. Therefore, the respondents expressed very positive attitudes towards digital competences and digital education.

The respondents also showed positive attitudes towards the use of various digital devices in physical education teaching and stated that they readily used them in their classes (video cameras, LCD projectors, MP3 players, computers, mobile phones, etc.). The findings prove that technology was more frequently used by female teachers, teachers with 0 to 10 years of teaching experience, and secondary school PE teachers. As regards the connection between digital education and the quality of PE teaching, students' achievements and the teacher's role, a statistically significant difference was

evident in the obtained responses regarding all three independent variables (gender, teaching experience and the school in which the teachers were employed, $p<0.05$). Namely, the effects of digitalisation on the quality of teaching, students' achievements and the teacher's role were more positively evaluated by female teachers, teachers with 0 to 10 years of teaching experience, and secondary school PE teachers. It is thus concluded that digital education exerts an enormous influence on the quality of teaching since its introduction enhances all aspects of teaching and contributes to the promotion of healthy lifestyles. Students become more motivated and active in class, they cooperate better with their peers and achieve better results in their personal growth and development. Reputation, self-confidence, personal integrity, cooperation with colleagues and sharing advice are only some of the elements that are influenced by the use of technology. This leads to the conclusion that digital education is closely related to the teacher's role in teaching.

The conducted research implies the importance of the study of this educational phenomenon and recommends its further promotion with the purpose of improving PE teaching as one of the most important school subjects.

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PEDAGOŠKI, KOGNITIVNI I METODOLOŠKI ASPEKTI DIGITALIZACIJE U FIZIČKOM VASPITANJU

Implementacija tehnologije digitalnog obrazovanja u školski predmet fizičkog vaspitanja (FV) predstavlja izazov savremenoj pedagogiji. Aktuelni rad naglašava značaj pedagoških, kognitivnih i metodoloških aspekata digitalizacije u fizičkom vaspitanju. U okviru istraživanja su ispitivani stavovi nastavnika FV u osnovnim i srednjim školama prema digitalizaciji u FV. Istraživanje ima tri cilja: 1. teorijski - pregled svih međunarodnih i nacionalnih izvora relevantnih za sagledavanje teorijskih aspekata uvođenja digitalizacije u nastavu FV; 2. kognitivni - proučavanje stavova nastavnika FV prema digitalizaciji u FV kao školskom predmetu; 3. primenljivost - doprinos podizanju svesti o značaju unapređenja FV. Metode koje su korišćene u empirijskom istraživanju bile su: deskriptivna metoda, tehnike anketiranja i skaliranja sa instrumentom upitnik sa skalom procene Likertovog tipa (DOUF/DEIP). Upitnik se sastojao od četiri zatvorena pitanja i skale koja je sadržavala 40 itema. Uzorak je obuhvatio 126 nastavnika FV iz Srbije. Rezultati su dobijeni upotrebom softvera za statističku obradu podataka SPSS verzija 24. U prikazu rezultata korišćeni su sledeći statistički parametri: frekvencija (f), procenat (%), aritmetička sredina (M), standardna devijacija (SD), Pearsonov hi-kvadrat test (ch^2), t-test i ANOVA F-test. Rezultati istraživanja pokazuju da se nastava FV podvrgava digitalizaciji i da nastavnici imaju pozitivan stav prema digitalnim kompetencijama, tehnologijama i prema vezi između digitalnog obrazovanja i kvaliteta nastave, akademskih dostignuća školaraca i uloge nastavnika.

Ključne reči*: fizičko vaspitanje, digitalizacija, tehnologija, nastavnici u osnovnim i srednjim školama, empirijsko istraživanje*

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Review article

THE PREVALENCE OF FOOT DEFORMITIES IN ATHLETES WITH VARIOUS SPORTS BACKGROUNDS

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Abstract. *Changes and deformities to the feet are frequent among athletes. The aim of this review paper is to determine the prevalence of foot deformities among athletes with various backgrounds, as well as to determine the influence of the deformities on motor task performance. The compiled studies were published between 2002 and 2018. The following electronic databases were used for the search: PubMed, MEDLINE, Google Scholar, EBSCO. The identified studies had to satisfy the following criteria: that they included athletes and that the subject of analysis were the differences in foot deformities in relation to performing motor tasks. Research papers on this topic were reviewed and analyzed. They are clearly organized in tabular form, with a clear outline of the details of the research. The results of 16 research papers are summed up. The most prevalent deformity among athletes is flat feet (pes planus). The studies indicate the various deformities which are prevalent in particular sports, and determine the changes in the feet of the athletes, in particular for the foot which plays a decisive role in certain sports. Individuals with flat feet scored lower results compared to individuals with normal arches in terms of time and reaction speed when performing motor tasks.*

Key words: *Foot, Deformities, Athletes, Influence, Frequency*

INTRODUCTION

The foot is one of the most complicated anatomical segments of the human body. It consists of 26 bones and 32 joints which enable the foot to perform two important functions: standing (static function) and walking (dynamic function) (Jovičić, 2007). Therefore, it must have sound structure in order to endure the forces active during standing, but to also adapt to the surface, function as a shock absorber, and be active during walking. The structure of the foot is such that the functions of three arches maintain stability and the necessary elasticity. Foot deformities lead to a disruption of

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static in the foot and affect the knee, which leads to changes in the shape of the foot, that is, the occurrence of a deformity in its internal and external structures. These deformities usually lead to deformities of the knee joint (Jovović, 2008). Furthermore, changes and deformities of the feet lead to a reduction in the physical abilities for the performance of various motor tasks.

An examination of the foot can be performed in several ways and by applying various methods. These include: a plantogram, podoscope, digitalized podography (CDP), etc. They can be used to successfully detect feet deformities, including flat feet (fallen arches, pes planus). There are no clear boundaries that indicate the completion of the formation of the arch, as there are no clear boundaries between normal arches and a deformity (Mosca, 1995). Research has indicated that the longitudinal arch develops spontaneously during the first decade of life and that it slowly rises (Staheli, Chew, & Corbett, 1987).

According to the etiology of emergence, foot deformities can be innate (congenital) and acquired. Feet deformities occur due to a disbalance in limb static and the proper appearance of the feet, a lack of proportion between the active strength of the feet and load. The calcaneus occupies the valgus position and this represents the first stage in the collapse of the longitudinal arch which is referred to as the pes valgus. If this stage is not stopped, it further leads to the collapse of the os naviculare and the os cuboideum and the lowering of the longitudinal and transverse arch which leads to the second stage which is known as the pes planovalgus. Along with the changes in the longitudinal and transverse arch, there is also a distancing of the head of the metatarsal bones and their lowering which represents the third stage of collapsed arches, or the pes transversoplanus. Clawfoot (pes excavatus) is a dynamic deformation which occurs as a consequence of the disrupted balance in the strength of the muscles of the lower leg and feet. Due to muscle insufficiency of the plantar extensors, especially the m. triceps surae, a disbalance between them and the dorsal flexors emerges. The disrupted balance creates a tendency for the front part of the calcaneus to rise, which in turn shortens the plantar aponeurosis, and the longitudinal arch of the foot rises, that is, a denivelation occurs between the ball and heel of the foot. In the case of a foot with normal arches, the difference in height between the ball and heel is approximately 10mm, while in the case of a claw foot it is significantly raised in favor of the heel. Pes equinovarus is one of the most frequent innate deformities. This deformity of the foot is complex and consists of 3 components: ankle equinus (limited upward bending motion), the varus of the foot (an inverted position, especially affecting the heel) and the adduction of the front part of the foot (inward angulation), which gives the foot a specific fallen and twisted look. The foot is in an inverted position, with a pressure point on the outer edge. Pes equinus is a deformity where the foot during contact with the ground is relaxed and most of the pressure is asserted on the tips of the toes, or the upper third of the metatarsus. The foot is in a position of a profound plantar extension. Due to the weakness in the dorsal flexors, the ball of the foot is lowered (Dimeglio, Bensahel, Souchet, Mazeau, & Bonnet, 1995; Živković, 2009).

Physical activity (PA) is encouraged from childhood since it is an important tool in the sedentary habit prevention. From the biomechanical point of view (considering plantar pressure, kinematics, and electromyography), even small alterations in foot and ankle structure or alignment is reflected in sports performance (Arévalo-Mora, Reina-Bueno, & Munuera, 2016). Although sports activities positively affect the reduction of the deformity, the majority of researchers came to the conclusion that a large number of repeated movements in sports and muscle imbalances affect the incidence and development of certain postural disorders (Stošić, Milenković, & Živković, 2011). Also, maintaining unnatural positions for

extended periods of time could lead to the development of deformities, which is usually found among professional cyclists (Muyor, Casimiro, Lopez-Minarro, & Alacid, 2012).

The aim of this review paper is to determine the prevalence of foot deformities among athletes with various sports backgrounds, as well as to determine the influence of the deformities on motor task performance.

METHODS

With the aim of compiling a large number of research papers which dealt with the subject matter of the review paper, the following electronic databases were searched: PubMed, HRCAK, MEDLINE, ERIC, Google Scholar, Kobson, SCIndex and ScienceDirect. Papers published from 2002 to 2018 were reviewed. All of the papers had been published in leading sports science journals, while the main focus of attention was on the papers published from 2005 to 2018. In order for them to be included in the final analysis, they had to meet the following criteria: that the research had to include participants of both sexes, that it included athletes who had no record of foot injury prior to the testing, and that the paper was written either in Serbian or in English. The key words used during the database search included: foot deformities in sports, influence of sport on the foot, and type of foot deformities. The overview and analysis of the research papers was carried out based on: the references (the first author and year of publication), the number of participants, sex, age, type of PA (sport), means of measuring the deformity, type of deformity, and the research results.

Based on the key words, 467 papers were identified. Based on the date of publication, papers published prior to 2002 were excluded from the overview. Other papers were excluded based on their title, abstract, or the subject matter which did not match the subject matter of this paper. Further, papers which focused on participants who had undergone treatment for foot injury were also excluded.

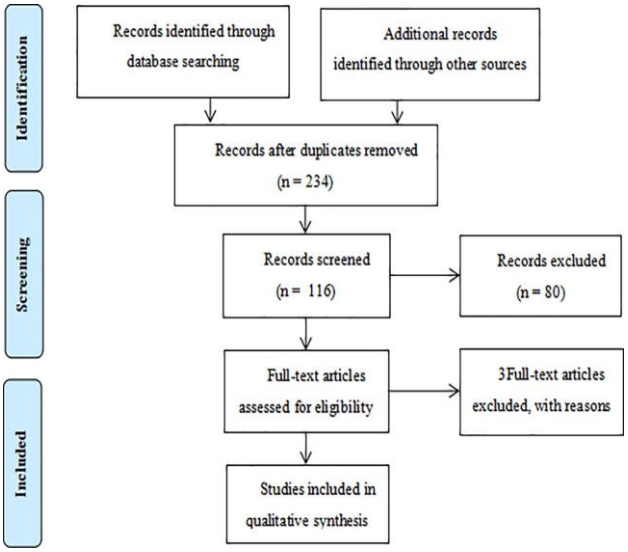

Fig. 1 PRISMA Flow Diagram for Systematic Reviews for the research related to the given topic

The final analysis included 16 studies which were compiled and analyzed based on the previously mentioned parameters and methods. The studies included male and female participants. All of the studies which were taken into consideration had the following aim: to determine the influence of sport on the arches of the feet, the influence of the shape of the arch on the physical and sports results, and the influence of the arches of the feet on the risk of injury to the lower extremities.

Table 1 An overview of 16 studies which met the set requirements

Authors	Participants				Method-Type of deformity	Aim	Results	Conclusion
	n	Gender	Age	PA-Groups				
Michelson et al. (2002)	196	M 143 F 53	19-23	Baseball, basketball athletics, field hockey, American football, lacrosse, football, swimming tennis and volleyball	Pl FF	Determining prevalence of foot deformities in various sports and correlation between injuries and deformities	The influence of FF on the injuries to the lower extremities: baseball 5 (15.6%), basketball 1 (0.5%), athletics (long distance) 2 (11.8%), field hockey 1(9.1%), American football 4 (12.1%), lacrosse 2 (9.5%), football 5 (17.9%), swimming 5 (26.3%), tennis 2 (1.0%), volleyball 3 (37.5%).	Athletic population that is representative of collegiate athletics, the existence of FF does not predispose to subsequent lower extremity injury.
Ledoux & Hillstrom (2002)	19	M 19 F x	21- 38	E1-11 E2-8 Recreational PA, walk and run for 10 m.	Pd FF and NA	Determining force values at different foot locations among athletes with normal and foot with deformities	11 NA and 8 FF. ↑ maximal force in the side and ball of the foot for FF compared to NA (p=0.008), ↑ loading amount which is transferred through the side part of the F in FF, (p=0.0064).	Data represent new information on the effect of foot type on foot function and serve as guidelines for further experimental protocols.
Aydog et al. (2005)	146	M 146 F x	18- 30	E1-116 Football, wrestling, weightlifting, handball, gymnastics C-30 inactive	Pd FF and HA	To determine the effect of various sports on sole arch indices	The influence of PA of E and C between the arches of the LF and RF: LF 48.76% and RF 52.42%, 24 wrestlers LF 63.77% and RF 68.22%, 19 weightlifters LF 47.67% and RF	The AI of the gymnasts and wrestlers were significantly different from those of other athletes

							51.85%, 32 handball players LF 41.99% and RF 44.86%, 22 gymnasts LF 30.56% and RF 30.06% and 30 inactive LF 53.73% and RF 55.77%.	studied, and those of the gymnasts and handball players were significantly different from those of non-athletic controls.
Aydog et al. (2005a)	39	M 39 F x	18-30	E-22 gymnasts and C-17 inactive	Pd FF and HA	To evaluate the relation between muscle strength of the ankle joint and foot structure (deformities) in gymnasts.	The differences between the arch angle of the RF and LF between E and C in r with isokinetic torque of the ankle (%): gymnasts RF 29.1% and LF 34.65% and inactive RF 30.3% and LF 32.27%.	That bilateral foot AI and ankle dorsiflexion muscle strengths are lower in E than C, and there is r between the AI of E and their eversion strengths.
Chuckpaiwong et al. (2008)	50	x	20-29	E1 NA E2 FF Collective and individual sports, walk and run for 10 m (in a neutral gym sneaker).	Pl FF and NA	To determine if FF have altered plantar loading patterns when compared to NA during both walking and running.	34 NA and 16 FF. interaction between walking and running and FF and NA.↑ normalization of maximal force (medial part) during walking in FF compared to NA ($p=0.001$), ↑ in contact surface ($p<0.001$), maximal force ($p<0.001$) and pressure ($p<0.001$) during the run test compared to the walk test. ↓ r of force and reaction time during the run in the heel of the F ($p<0.001$), ↓ maximal pressure beneath the side of the foot compared to NA ($p = 0.05$).	That participants with FF could be at a lower risk for injury (lateral column metatarsal stress fractures).

Chou et al. (2009)	18006	M 8883 F 9123	6-12	E1 E2 (by age and gender) Collective and individual sports	Epd FF, HA, HV, and HE	To determine the overall prevalence and differences between gender of four common foot deformities	Distribution of the deformities: FF 2499 (13.88%), HA 237 (1.32%), HV 252 (1.40%), HE 599 (3.33%).	There are strong association between flexible flatfoot and hindfoot valgus.
Queen et al. (2009)	22	x	21 – 29	E1-12 NA E2-10 FF Cross-cut, side-cut, shuttle run, and landing from a simulated lay-up	Pd FF and NA	To determine if foot type (FF or NA) resulted in loading differences during four sport-specific tasks	↑ contact surface in FF, cross cut test ($p = 0.001$) and landing from a simulated lay-up ($p = 0.039$), rearfoot ($p = 0.024$), medial midfoot ($p = 0.016$), and lateral midfoot ($p = 0.014$), duration of force acting on inside part is longer ($p = 0.04$) and on outside part of foot ($p = 0.019$), ↑maximal normalization of force on side ($p = 0.027$) and inside of foot ($p = 0.005$). Shuttle test ↑ FF duration of the effect of force in lateral midfoot ($p = 0.037$), both the medial ($p = 0.049$) and lateral ($p = 0.006$) midfoot	That participants with NA could be at a lower risk for medial and lateral midfoot injuries such as metatarsal stress fractures.
Schenkel, (2010)	1	F 1	15	Basketball	CT Talocalcaneal coalition	Investigation of basketball athlete with activity related chronic bilateral dorsal foot pain and stiffness	12% of the recorded cases of chronic foot pain occur as a result of this diagnosis. The influence of PA in basketball stimulated the development of Talocalcaneal coalition without any preventive analyses or treatment in the early phases.	In adolescent athletes, delayed diagnosis and inappropriate management may lead to decreased chance of return to competitive activity.

Carson et al. (2012)	26	M 26 F x	17 – 18	E1-16 NA E2-10 HA American football, cross over walk and run (barefoot and in sneakers) for 5 m x 12 m	CDP FF, NA and HA	To determine if differences in plantar loading in football players occur during both walking and pivoting movements	16 NA, 6 HA and 4 FF. ↑ HA maximal force in side of F ($p = 0.008$) and inside of F ($p < 0.001$) compared to NA. ↑HA, force duration in side of F ($p = 0.044$), but not in other parts of the F.	That loading patterns differ between football players with NA and HA structure, which could possibly influence injury risk in this population.
Đurić et al. (2013)	35	M 35 F x	8-15	Volleyball	Pl FF and HA	To detect the presence of the suspended arch of the foot among the students of the volleyball players	The influence of PA in volleyball on the AI (%) is: LF, NA 22.8% RF 20%, stage 1 flat feet 60% RF 62.8%, stage 2 flat feet 5.7%, RF 5,/% and stage 3 flat feet 11.4%, RF 11.4%.	That large number of the volleyball players have deformed arch of the foot, even 88.58%.
Mani et al. (2013)	126	M 24 F 39	27-84	Collective sports and recreation	Pl and Q FF	To validate the foot and outcome score for use in evaluating patients with hindfoot deformity, specifically acquired FF.	39 participants who took part in some form of PA had been diagnosed with FF.	That the foot and outcome score for acquired FF with acceptable construct and content validity and reliability.
Nakhostin et al. (2013)	100	x	14-17	E1-50 NA E2-50 FF Moderate PA (collective sports with a ball)	Pl FF and NA	To evaluate influence of flexible FF on several PA factors that are necessary for sport performance	The influence of FF and NA on PA, significant difference between E1 and E2, ($p=0.05$) for two tests: the T-test of agility and static balance between the groups with NA and FF.	Presence of a plenty of controversies suggests more works in this domain.

Janković et al. (2014)	30	M 30 F x	11-13	E-30 Football	Pl FF and HA	To present and analyze the foot status of the participants of football players	The influence of PA in football on AI of F (%): NA 37%, FF stage 1 50%, FF stage 2 10% and FF stage 3, 3.33%.	That large number of participants have the impaired foot arches, even 76,67%.
Powell et al. (2014)	20	M x F 55	18-30	E1- 10 HA E2- 10 FF Recreational PA and moderate intensity barefoot running (3 m/s).	Pl FF and HA	To quantify the differences in ankle dynamic joint stiffness, and ankle braking work and ankle propulsive work during stance phase of running	During the run, ↓angle in HA, ↓ duration of movement during contact with the surface and propulsion, ↓ power affecting the ankle among the HA compared to the FF group (p=0.040).	That HA and FF athletes exhibit unique biomechanical patterns during running and may be related to lower extremity injury.
Puzović et al. (2015)	64	M 43 F 21	10-12	E1-43 E2-21 (by gender) Basketball	Pl FF	To estimate the prevalence of foot deformities among basketball players, and differences between different gender and age.	The influence of PA in basketball on the changes to the arches of the feet (%) is: M 83.7% and F 23,8%.	Despite basketball training, participants have a high prevalence of deformities, especially boys who stand out with the high prevalence of FF.
Arévalo-Mora et al. (2016)	187	M 90 F 97	10-12	E1-97 NA E2-HA E3-37FF Standing depth jump, triple alternate leg jump, vertical jump, 10 m x 5 m run around cones, 20 m sprint, static and dynamic balance and an agility test	Pl FF, NA and HA	To determine whether NA, FF, or HA corresponded to better performance of certain motor tests in children	96 NA, 54 HA and 37 FF. On 8 of the 9 tests the participants with HA scored better results. ↑FF in dynamic balance relative to others. ↑HA relative to FF on static, (p=0.062), ↑NA compared to HA on the agility test, (p=0.048).	Participants with a certain foot type did not achieve better motor performance in the nine trials tested.

Legends: N-Number of Participants; M-Male; F-Female; Pd-Podoscope; Epd-Electronic Podoscope; Pl-Plantogram; CDP-Computerized Digital Podography; CT-Computer Tomography Scan; PA-Physical Activityy; E-Experimental Group; C-Control Group; AI-Arch Index; FF-Flat Feet (Pes Planus); NA-Normal Arch; HA-High Arch (Clawfoot) (Pes Excavatus); HV-Hallux Valgus (Bunions); HE-Heel Eversion (Hindfoot Valgus); F-Foot; Q-Questionnaire; R-Correlation; X-No Data; ↓-Decreasing; ↑-Increasing.

DISCUSSION

The aim of this systematic review is to collect and analyze research that studied the prevalence of foot deformities among athletes with various sports backgrounds, as well as to determine the influence of the deformities on the motor task performance. Although different motor tasks, in collective or basic sports, lead to different types of foot loading, based on split results from current research results deformities and changes to the foot arch are visible in both cases.

Results indicating greater prevalence of foot deformities in the younger population, with flat feet being the more prevalent, can be found in the research of Chou and associates (2009). Among 18006 elementary school students aged 6 to 12 who took part in obligatory PA and sports games played with a ball, the distribution of foot deformities was analyzed with an electronic podometer: flat feet 2499 (13.88%), clawfoot 237 (1.32%), bunions 252 (1.40%) and Hindfoot valgus 599 (3.33%). Among the boys the distribution was as follows: a flexible flat foot n=1593 (8.85%), clawfoot n=84 (0.47%), bunions n=46 (0.26%) and Hindfoot valgus n=346 (1.92%), and among the girls: flexible flat foot n=2499 (13.88%), clawfoot n=237 (1.32%), bunions n=252 (1.40%) and Hindfoot valgus n=599 (3.33%). Also, it was determined that the condition known as flat foot is more prevalent among boys of all ages than among girls $p<0.5$, and that girls aged 11 and 12 have a higher prevalence of clawfoot compared to boys of the same age, $p<0.074$ and $p<0.063$. Additional results, which further support such findings by studying athletes involved in various sports, can be found in the research of Đurić, Ilić, & Nešić (2013). The authors focused on the influence of volleyball training on the arches of the feet. On a sample of participants (n=35), aged eight to 15, by using a plantogram and the Thompson technique, it was determined that eight of them have normal arches, 21 flat feet stage 1, 2 flat feet stage 2, and 4 have flat feet stage 3. The Russian method also recorded the same distribution results. It was also determined that feet correction was required in 88,58% of the participants. In addition to volleyball players, basketball players also have flat feet, which is shown in the research of Puzović and associates (2015). The authors focused on basketball players aged 10 to 12 in order to determine the prevalence of foot deformities in basketball. Of a sample of 64 participants (43 boys and 21 girls,) using a plantogram, they obtained results that out line differences in terms of gender and the prevalence of the condition known as flat feet, through statistically significant results ($p=0.001$) for the boys (n=36) 83.7% and for the girls (n=5) 23,8%. Also, the results confirm a greater prevalence of flat feet in a younger population of basketball players aged 10, 85.71%, with significant differences in terms of age ($p=0.036$). An interesting observation was presented in a case study by Schenkel (2010), who established the diagnosis of the Talocalcaneal coalition in a female basketball player who had three years of training and reported experiencing pain in her foot. The diagnosis was established by a scanner. Out of all the noted cases with reported foot pain, the aforementioned diagnosis was determined in 12%.

The influence of football training on changes in the arch index (flat foot) was the focus of the research carried by Janković et al. (2014). Although they did not study the correlation of prevalence of foot deformities between the dominant and non-dominant leg among 30 football players aged 11 to 13, the authors indicated the percentage of deformities for each foot separately. Clear differences can be noted in the number of deformities between the legs using the Thompson technique and Russian method. The

Thompson technique provided the following results: 37% of all cases have normal arches, 50% flat feet stage 1, 10% flat feet stage 2, and 3.33% flat feet stage 3. By using the Russian method normal arches were determined in 50% of the cases, flat feet stage 1 in 33.34%, flat feet stage 2 in 13.33% and flat feet stage 3 in 3.33% of the total number of participants (n=30). As many as76.67% of the participants do not have the same arch index of the foot for both legs: in the case of the left foot 11 have normal arches, 15 flat foot stage 1, three flat foot stage 2, and one has flat foot stage 3 according to the Thompson technique; and in the case of the right foot 10 players have normal arches, 18 flat foot stage 1, one flat foot stage 2, and one flat foot stage 3 also according to the Thompson technique.

More complex research that included a greater number of different sports and types of physical training specific for that sport, and control groups with physically non active participants was carried by Aydog and associates (2005). Based on 116 older participants, aged 18 to 30, results were obtained for the left and right foot arch for football players, wrestlers, weightlifters, handball players, and gymnasts. The results indicated changes in the arch index of the right foot among the gymnasts, where the arch was lower compared to that of the football players, wrestlers, and the control group ($p<0.01$). A statistically significant difference was determined in favor of the wrestlers for a high arch of the right foot compared to football players, handball players, weightlifters, gymnasts, and the control group ($p<0.03$). A statistically significant difference for the fallen arch of the left foot was determined in favor of the gymnasts compared to the wrestlers, and control group ($p<0.001$). A statistically significant difference was determined for the high arch of the left foot in favor of gymnasts compared to football players, and handball players ($p<0.007$). A statistically significant difference was determined for the fallen arch of the left and right foot in favor of the handball players compared to the control group ($p<0.049$). The results indicate a weak correlation between the arches of the left and right foot of the football players ($r=0.31$), handball players ($r=0.69$), and wrestlers ($r=0.56$). A high correlation was noted for gymnasts ($r=0.96$), weightlifters ($r=0.88$), and control group ($r=0.80$). The biggest difference between gymnasts and handball players compared to the control group was also noticed, while wrestlers and gymnasts have the most deformities compared to the other athletes. Results that further support these findings are represented in the research of Michelson, Durant, & McFarland (2002).

In addition to the mentioned goal, the authors also expanded the analysis by comparing the degree of risk of injuries among participants with some form of foot deformity. The results pertaining to prevalence among 196 participants, aged 19 to 23 years, were shown by sport, in baseball (total n=32), n=5 (15.6%), basketball (total n=20), n=1 (0.5%), athletics (long distance running) (total n=18), n=2 (11.8%), field hockey (total n=11), n=1 (9.1%), American football (total n=11), n=4 (12.1%), lacrosse(total n=21), n=2 (9.5%), football (total n=28), n=5 (17.9%), swimming (total n=19), n=5 (26.3%), tennis (total n=15), n=2 (1.0%) and volleyball (total n=8), n=3 (37.5%), while cases of flat feet were also determined (a total of 56 participants). The independent risk factor for the lower extremities does not exist for contact sports. Differences in terms of sex have a more significant correlation with injuries to the feet and lower extremities. In the case of women, the factor is greater than in the case of men ($p<0.5$ and $p<0.009$). Out of 99 twisted ankles, 14.1% of the cases also reported the presence of flat feet, and a diagnosed flat foot without a twisted ankle was found in 17.9% of the cases (52 of 291, $p>0.39$).

A research of the influence of different motor tasks on the arch index was carried by Chuckpaiwong, Nunley, Mall, & Queen (2008). A sample of 50 participants was included in an analysis of athletes involved in collective and individual sports, who performed a run and walk test in shoes and barefoot. Using an apparatus installed in the shoes of the participants, and on the surface on which the testing was performed, the researchers could monitor the contact surface, the distribution of the maximal force, pressure on the feet during the PA, and amortization of force during the performance of the motor tasks. A statistically significant difference was noted for the normalization of maximal force in the medial part of the feet during walking, which was higher for the group with flat feet compared to the group of athletes with normal arches ($p=0.001$). There was an increase in surface contact ($p<0.001$), maximal force ($p<0.001$) and pressure ($p<0.001$) during the running test compared to the results of the walking test between the two groups, in favor of the group with normal arches. The relationship between force and reaction time significantly decreased during the running test in the heel ($p<0.001$), and a significant decrease in the maximal pressure below the external part of the foot was noted compared to the group with normal arches ($p=0.05$).

The contact reaction and the amount of force during the propulsion phase during running were compared between a sample of 10 athletes with a diagnosed flat foot deformity and sample of 10 athletes with a clawfoot deformity (Powell, Williams, Windsor, Butler, & Zhang, 2014). The statistically significant difference between the two groups of participants in the amount of static strength which was measured for the ankle was smaller in the case of athletes with a determined flat foot deformity ($p=0.040$).

Furthermore, research carried out by the Arévalo-Mora and associates (2016) focused on the differences in the results of performing the following tests: the standing depth jump, the standing triple alternate leg bound, the vertical jump, the 10 m x 5 m run around cones, a 20 m sprint with a high start, static and dynamic balance, and the test of agility, on a sample of 187 participants with flat feet, high and normal arches. The only test where a statistically significant difference in favor of the participants with flat feet compared to the other athletes was found is the dynamic balance test ($p=0.062$).

Finally, the research of Aydog, Tetik, Demirel, & Doral (2005a) focused on the differences in the muscle strength of the feet (static exercises) between gymnasts and a control group with healthy arches. The results indicate a difference in strength of the dorsal flexion of the feet among gymnasts with flat feet compared to the control group. A correlation between the arch index and strength was not determined for the control group. A statistical significance for the correlation was noted between twisting the ankle outside and inside, and the arch index among gymnasts ($r=0.41$, $p=0.02$). The mean value of the arch index of the left and right foot among the gymnasts and the control group is: 31.4 (29.1), 34.01 (34.65); 60.01 (30.3), 63.75 (32.27).

CONCLUSION

Based on the results obtained from the studies, it can be concluded that although there are a large number of different studies, the final result of the distribution of foot deformities among different athletes could not be defined. Although the prevalence of flat feet and a clear difference in terms of gender was noted even among the younger population, the impact of various types of training in collective and basic sports was not clearly

determined. In the case of girls and women, a greater level of development of bunions was noted (hallux valgus) compared to boys and men, and the aforementioned change to the arches occurs due to inadequate PA and inadequate footwear. Moreover, a diagnosed change in the arch of the foot increases the risk of injuries to the lower extremities in all types of sports. Although foot deformities can be noted among athletes such as wrestlers and gymnasts who have more pronounced flat feet due to barefoot training, certain athletic exercises performed barefoot have a preventive significance against injuries of the lower extremities. The deformity known as clawfoot is noticed in handball players.

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PREVALENCA DEFORMITETA STOPALA SPORTISTA SA RAZLIČITIM SPORTSKIM ISKUSTVOM

Promene i deformiteti stopala učestala su pojava kod sportista. Cilj ovog preglednog rada je utvrđivanje rasprostranjenosti deformiteta stopala kod različitih sportista, kao i utvrđivanje uticaja deformiteta na izvođenje motoričkih zadataka. Prikupljanje radova obuhvatalo je period izdavanja između 2002. i 2018. godine. Za pretraživanje literature korišćene su sledeće elektronske baze: PubMed, MEDLINE, Google Scholar, EBSCO. Pronađena istraživanja moraju da zadovolje zadate kriterijume: da su istraživanja vršena na sportistima i da su analizirane razlike kod deformiteta stopala u rezultatima izvođenja motoričkih zadataka. Pregledani i obrađeni su istraživački radovi koji se tiču ove teme i problema rada. Uredno su razvrstani u tabeli koja i prikazuje detalje radova. Sumirani su rezultati iz 16 naučno istraživačka rada. Najzastupljeniji deformitet kod sportista je ravno stopalo (pes planus). Istraživanja pokazuju različite deformitete koji su zastupljeni u određenim sportovima, takođe su ustanovnjene promene na stopalu na nozi sportiste koja ima dominirajuću ulogu u određeneim sportovima. Ravno stopalo ima najslabije vrednosti rezultata u odnosu na normalan tip stopala za vreme i brzinu reakcije pri izvođenju motoričkih zadataka.

Ključne reči: *stopala, deformiteti, sportisti, uticaj, učestalost*

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Research article

PHYSICAL EDUCATION: PRACTICE, CESSATION AND RESUMPTION IN UNTRAINED SAUDI COLLEGE STUDENTS

UDC 796.371.212 (532)

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Abstract. *The aim of the present study was twofold: firstly, to verify whether two classes a week of Physical Education (PE) are sufficient to improve physical fitness in college students. Secondly, to ascertain the effect of PE practice, cessation and resumption on the mentioned students. Thirty (30) untrained Saudi college students attended PE lessons twice a week for nine weeks. Subsequently, they were inactive for nine weeks, and finally, they attended PE classes again another period of nine weeks. After the two nine-week periods of PE, the participants improved their strength, endurance, speed and agility. The period of inactivity implied the loss of all the adaptations attained during the first nine weeks of practice, except muscular endurance in the trunk flexor muscles. Two classes a week of PE during nine weeks improve physical fitness in untrained university students. These improvements almost entirely decay after nine weeks of inactivity, but can be recovered with another nine weeks of PE classes. Individuals who resume PE lessons after nine weeks of PE followed by a nine-week inactivity period, could attain higher improvements in specific physical capacities (muscular endurance, cardiovascular endurance, speed and agility).*

Key words: *Physical Education, Continuity, Frequency, Reversibility*

INTRODUCTION

Current scientific evidence indicates that university students neither practice enough physical exercise, nor comply with the global recommendations on Physical Activity (PA) established by the World Health Organization. This phenomenon is not limited to specific countries, but affects college students from all continents (Irwin et al., 2004;

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Clemente, Nikolaidis, Martins, & Mendes, 2016; Griban et al., 2020; Lipert et al., 2020; Mandić et al., 2020). In Saudi Arabia, recent studies addressing this aspect have reported low levels of PA practice (El Bcheraoui et al., 2016; Almutairi et al., 2018).

Besides, some research indicates that as students complete each academic year, this trend becomes accentuated. Junior students practice less PA than sophomore students, who, in turn, practice less than freshmen students (Meckel, Galily, Nemet, & Eliakim, 2011).

To reverse this situation, Physical Education (PE) teachers have the responsibility to foster lifetime habits of PA practice among the students, promoting a constructive and healthy use of leisure time (Fausto-Iván & Aldas-Arcos, 2019; Hall-López, 2020). Their daily work is essential in improving public health and people's quality of life since PE has a positive impact on students at physical, psychological and social levels (Harris, 2015; Wang, 2019).

The practice of PA also reduces the appearance of risk factors associated with chronic diseases. Therefore, PE teachers should try to improve the motor competence and motivation towards exercise of their students, enabling them to dominate a wide variety of sporting disciplines to ensure PA adherence (Harris, 2015).

However, to benefit from the health effects derived from participating in PA programs, the practice should be frequent and continuous (Zamarripa-Rivera, Ruiz-Juan, López-Walle, & Fernández, 2014). Otherwise, there would be a progressive loss of the adaptations attained through exercise, following the principle of reversibility (Tsolakis, Vagenas, & Dessypris, 2004).

As for the weekly frequency of practice, recent research has analyzed the PE Curriculum time allocation on Primary and Secondary Education (Kühr, Lima, Grøntved, Wedderkopp, & Klakk, 2020). However, very few studies have addressed this aspect in college students. Even so, it has been verified that, at the university level, the higher academic workload and long hours of study impede the PA practice as often as needed (Calestine, Bopp, Bopp, & Papalia, 2017).

Regarding the continued practice of PA, in countries such as Saudi Arabia, it has been found that participants significantly decrease the frequency of regular practice of PA once they enter University. Undoubtedly, the higher academic demand makes it difficult for college students to exercise regularly throughout the year (Alkhateeb et al., 2019).

This circumstance is aggravated at certain times, such as final exam periods, and could, in some cases, lead to a temporary cessation of practice. If so, we would be talking about PA practice, cessation and resumption. This phenomenon, known in the field of sport as training, detraining and retraining, has been studied in different age groups (Psilander et al., 2019; Blocquiaux et al., 2020). However, no previous study has examined the effect of PE practice, cessation and resumption in college-age students.

In this context, the aim of the present study was twofold: firstly, to verify whether two weekly sessions of PE are sufficient to improve physical fitness in Saudi college students. Secondly, to ascertain the effect of PE practice, cessation and resumption on the mentioned students.

METHODS

Participants

Thirty (30) Saudi male college students (Age: 19.11±0.56; Mass: 76.31±11.42; Height: 175.64±6.72; BMI: 24.69±3.42) voluntarily participated in the present study. The

inclusion criteria were: a) Have not practiced either regular or structured physical exercise in the last five years; b) Did not suffer injuries or chronic diseases; c) Were a non-smoker; d) Had a BMI lower than 30; and e) Were not on a diet.

All of the participants were informed about the objectives, risks and benefits derived from their inclusion in the study. They also signed an informed consent form indicating their willingness to participate. The present study was carried out according to the Declaration of Helsinki ethical principles. It was also approved by the Institutional Review Board of the Bioethics Committee of Price Sultan University (Riyadh, Saudi Arabia).

Procedures

The research was carried out at Prince Sultan University within the "Physical Education I" and "Physical Education II" courses. Both are mandatory courses for all freshmen students and are respectively taught in the first and second semester twice a week.

The intervention had a total duration of 27 weeks (see Figure 1). Both in the intervention period 1 and 2, an individual sport, a racket sport and a team sport were practiced for three weeks, as set out in the Academic Curriculum. PE lessons were held on Sunday and Tuesday, from 2:00 p.m. to 2:50 p.m. or from 3:00 p.m. to 3:50 p.m. The period of inactivity between the 10th and the 18th week coincided with the period of final exams of the first semester (three weeks), with the holiday week between the first and second semester, and with the first five weeks of the second semester, in which only theoretical contents were taught in the Physical Education II course. During this period of inactivity, the study participants were not required to take part in physical activity. As for the tests, the pre-test 1 (PreT1) and pre-test 2 (PreT2) were carried out the week before starting the intervention period 1 and 2, while post-test 1 (PT1) and post-test 2 (PT2) were carried out respectively in the ninth and 27th week, 48 hours after the last PE class.

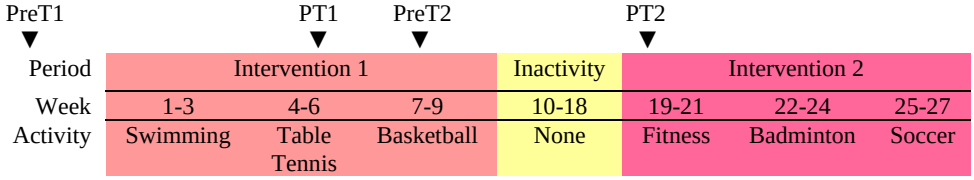

Fig. 1 Intervention timeline

The session content of intervention periods 1 and 2 is detailed in tables 1 and 2, respectively. It was designed based on the proposal of Fernández-Bustos, Méndez-Giménez, & Sánchez-Gómez (2018). The duration of each session was 50min. In the first 10min, a warm-up was carried out. It consisted of two phases. An initial general phase, which included muscle activation and joint mobility, and a specific phase, comprising sport-specific movements. Likewise, the last five minutes of each session were devoted to cooling down by performing jogging and stretching exercises. During the session, the following teaching methodological guidelines were followed (Ramos, 2000): a) Increasing time for instruction; b) Reducing transition time; c) Avoiding time-consuming explanations and demonstrations. d) Using feedback to improve student motivation; e) Avoiding elimination games and activities; and f) Once the students learned the basic skills of each sport, activities to apply them in real game situations were proposed.

Table 1 Intervention period 1. Sequence of contents

	Swimming	Table Tennis	Basketball
Session 1	Breathing, flotation and propulsion	Familiarization exercises with a racket and ball. Backhand and forehand	Drills and games to practice low and speed dribble without and with opposition
Session 2	Crawl: Analytical exercises, kicking and coordination	Backhand, forehand and service	Chest, bounce and overhead pass without and with opposition. 10 pass game
Session 3	Crawl: Arm stroke, contrast exercises, and exercises to reduce drag	Short explanation (Tactics and rules). Table tennis match pairing the players according to their skill and ability level	Lay-up. Mid-range shot. Free Throw. Game of 21
Session 4	Backstroke: Analytical exercises, kicking and coordination	Tournament (singles)	Dribbling: Reverse, between the legs, behind the back. 3x3 game
Session 5	Backstroke: Arm stroke, contrast exercises, and exercises to reduce drag	Tournament (doubles)	Short explanation (Tactics and rules). Basketball game
Session 6	Lifesaving introduction: Lifesaving swimming. Manikin carry with and without material	King of the court game	Tournament

Table 2 Intervention period 2. Sequence of contents

	Weight training	Badminton	Soccer
Session 1	Resistance training: Intensity: 58% 1RM Sets: 3 Reps: 14 Rest: 1min Number of exercises: 8 (lower body, core and upper body)	Familiarization with the racket and shuttle. Clear-drop; forehand-backhand	Pass. Control. Rondo game
Session 2	Idem session 1	Clear-lop; forehand-backhand; lob-smash. Service	Pass. Control. Dribbling. Team possession
Session 3	Resistance training: Intensity: 62% 1RM Sets: 3 Reps: 12 Rest: 90sec Number of exercises: 8 (lower body, core and upper body)	Short explanation (rules: singles and doubles). Practice of the basic shots. Game (singles)	Shooting. Skill Circuit: Passing, Dribbling and Shooting
Session 4	Idem session 1	Tournament (singles)	Practice of defensive transitions and attacks. Soccer game with 3 goals
Session 5	Strength training: Intensity: 66% 1RM Series: 3 Reps: 10 Rest: 2min Number of exercises: 8 (lower body, core and upper body)	Explanation (Tactics) Tournament (doubles)	Brief explanation (rules and tactical aspects). Soccer game 3x3
Session 6	Idem session 1	King of the court	Soccer tournament

Evaluation

The following five tests were used in the PreT1, PreT2, PT1 and PT2:

1-minute sit-up test (SU): It was used to assess the muscular endurance of the trunk flexor muscles. It was included due to its high reliability (Waldhelm & Li, 2012). The objective of the test was to perform as many sit-ups as possible in 1min. The materials used were a Delta Fitness© mat (Jeddah, Saudi Arabia) and a Casio© digital stopwatch model HS-3V-1BRDT (Mathura, New Delhi, India). To perform this test, the protocol set by the American Alliance for Health, Physical Education, Recreation and Dance (1980) was followed. The participant was in the supine position on a mat, with arms crossed over his chest, and knees bent at 90°. His feet were held on the ground by one partner. Only correct repetitions were registered. That is to say, the participant had to touch the mat with his scapulas when extending the trunk, and with his elbows on the knees when bending the trunk. Each participant had one attempt.

1-minute push-up test (PU): It was included due to its high validity and reliability (Hashim, Ariffin, Hashim, & Yusof, 2018). It was used to assess the muscular endurance of the upper body muscles. The material used was the same as in the previous test. The student was in the prone position, with his hands under the shoulders, fingers pointing forward and elbows bent at 90°. The trunk and lower extremities were aligned. The participant had to perform as many push-ups as possible in 1min. Only correctly performed repetitions were registered, meaning, those repetitions in which the student fully extended his arms when raising the trunk. And later, bent his elbows at a 90° angle when lowering the body. Each participant had one attempt.

Standing long jump (SLJ): It was used to assess the explosive strength of the lower body due to its high validity and reliability (Fernández-Santos, Ruiz, Cohen, González-Montesinos, & Castro-Piñero, 2015; Reid, Dolan, & Debeliso, 2017). To carry out this test, a Gamecraft© Carpeted Long Jump Mat (Dublin, Ireland) was used. The participant stood behind the take-off line with his feet parallel. The objective of the test was to jump as far as possible, landing with both feet simultaneously. The measurement was taken from the take-off line and the nearest back of the heel. Each participant had two attempts.

4x10m shuttle run test (SHR): It was used to measure speed and agility, and was selected due to its reliability (Ramírez-Vélez, Rodrigues-Bezerra, Correa-Bautista, Izquierdo, & Lobelo, 2015). The protocol established by the ALPHA health-related fitness test project was followed (Ruiz et al., 2011). The test was carried out on a non-slip sports court. Two parallel lines were marked on the floor at 10 meters. One sponge (B) was placed on the starting line, and two sponges (A and C) on the opposite line. On the teacher's signal, the student ran to the opposite line and picked up the sponge (A). Then, he returned to the starting line and exchanged sponge (A) for sponge (B). Afterward, he returned to the opposite line and exchanged sponge (B) for sponge (C), and later, he returned to the starting line to finish the test. The objective of the test was to carry out the actions previously described as quickly as possible. Time was recorded using a Timer© S4 Alge-Timing photocells (Lustenau, Australia). Each participant had one attempt.

1km run fitness test (1KM): This test was used to assess cardiovascular endurance. It was selected due to its high validity and reliability to estimate VO2max (García-García, Ramos-Bermúdez, & Aguirre, 2016). The participants had to complete 1KM as quickly as possible. The test was carried out on a Cybex 625T treadmill (Rosemont, Illinois, USA), in an air-conditioned fitness room, due to the high temperatures reached in Riyadh

most of the year. Participants had only one attempt. They were themselves responsible for selecting the speed of the treadmill.

Before conducting the tests, the participants performed a 10-minute warm-up, which included two phases of five minutes each: muscle activation and joint mobility. Likewise, the participants were encouraged to perform at their best in the five tests undertaken.

Statistical analysis

Results are presented as mean (standard deviation). The normality of the data was verified by using the Shapiro-Wilk test. Intraclass correlation coefficients were calculated for dependent variables, obtaining values greater than .91 on all of them. To assess the effect of each period on dependent variables, a one-way ANOVA with repeated measures was conducted. Since multiple comparisons were made, the Bonferroni correction was applied to adjust the confidence intervals. The effect size was estimated by using the partial eta squared parameter (η^2_p). Effect sizes of .02 were considered small, .13 medium, and .26 large (Bakeman, 2005). Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS Inc, version 22.0 Chicago, IL, USA). The level of significance was set at $p<.05$.

RESULTS

SU: The ANOVA showed a significant period effect, with a large effect size ($p<.001$; $\eta^2_p=.937$). As shown in table 3 and in Figure 2a, marks obtained on PreT1 were significantly lower than those attained on PT1 ($p=.003$), in PreT2 ($p<.001$) and on PT2 ($p<.001$). However, no significant differences were found between the PT1 and PreT2 results ($p=0.234$). The marks achieved on PT1 were significantly lower than those of PT2 ($p<.001$). Likewise, the PreT2 results were significantly worse than those of the PT2 ($p<.001$).

PU: The ANOVA indicated a significant period effect, with a large effect size ($p<.001$; $\eta^2_p=.753$). The PreT1 results were significantly lower than those of PT1 ($p<.001$), and those of PT2 ($p=.049$). However, there were no significant differences between the PreT1 and PreT2 marks ($p=.763$). The marks obtained on PT1 were significantly better than those obtained on PreT2 ($p<.001$). Nevertheless, no significant differences were observed between the PT1 and the PT2 results ($p=.094$). The PreT2 marks were significantly worse than those of the PT2 ($p<.001$) (see table 3 and figure 2b).

SLJ: The ANOVA revealed a significant main effect of period, and a large effect size ($p<.001$; $\eta^2_p=.787$). Marks attained on PreT1 were significantly lower than those accomplished on PT1 ($p<.001$), and in PT2 ($p=.047$). No significant differences were observed between the PreT1 and PreT2 results ($p=.986$). Marks attained on PT1 were significantly better than those obtained on PreT2 ($p=.007$), but there were no significant differences between PT1 and PT2 results ($p=.668$). It was also observed that the marks achieved on PreT2 were significantly lower than those attained on PT2 ($p<.001$) (see table 3 and figure 2c).

SHR: The ANOVA showed a significant main period effect, with a large effect size ($p<.001$; $\eta^2_p=.981$). The marks attained on PreT1 were significantly worse than those of PT1 ($p<.001$) and those of PT2 ($p<.001$). However, no significant differences were found between PreT1 and PreT2 results ($p=.11$). Marks achieved on PT1 were significantly better

than those of PreT2 (p<.001) and significantly worse than those of PT2 (p<.001). The PreT2 marks were significantly lower than those of PT2 (p<.001) (see table 3 and figure 2d).

1KM: The ANOVA revealed a significant main period effect, with a large effect size (p<.001; η^2_p=.930). Marks obtained on PreT1 were significantly lower than those attained on PT1 (p<.001) and on PT2 (p<.001). No significant differences were observed between PreT1 and PreT2 results. The marks of PT1 were significantly better than those of PreT2 (p<.001), and significantly lower than those of PT2. Finally, the results achieved in PT2 were significantly better than those accomplished on PreT2 ((p<.001) (see table 3 and figure 2e).

Table 3 Results obtained on the physical condition tests

	SU	PU	SLJ	SHR	1KM
Pre-test	35.61(3.93)	21.73(4.27)	168.33(11.54)	12.31(0.39)	6.13(0.74)
Pos-test 1	37.01(2.99) +	24.83(4.73) +	171.66(10.85) +	12.18(0.38) +	5.48(0.67) +
Pre-test 2	37.83(4.32) +	20.21(9.04) *	166.43(19.61) *	12.51(0.67) *	6.12(0.92) *
PreT1est 1	40.46(4.37) +*#	23.61(8.93) +#	174.09(21.59) +#	11.63(0.65) +*#	5.29(0.92) +*#

Note: +: Significant difference from the PreT1;
*: Significant difference from the PT1; #: Significant difference from the PreT2.

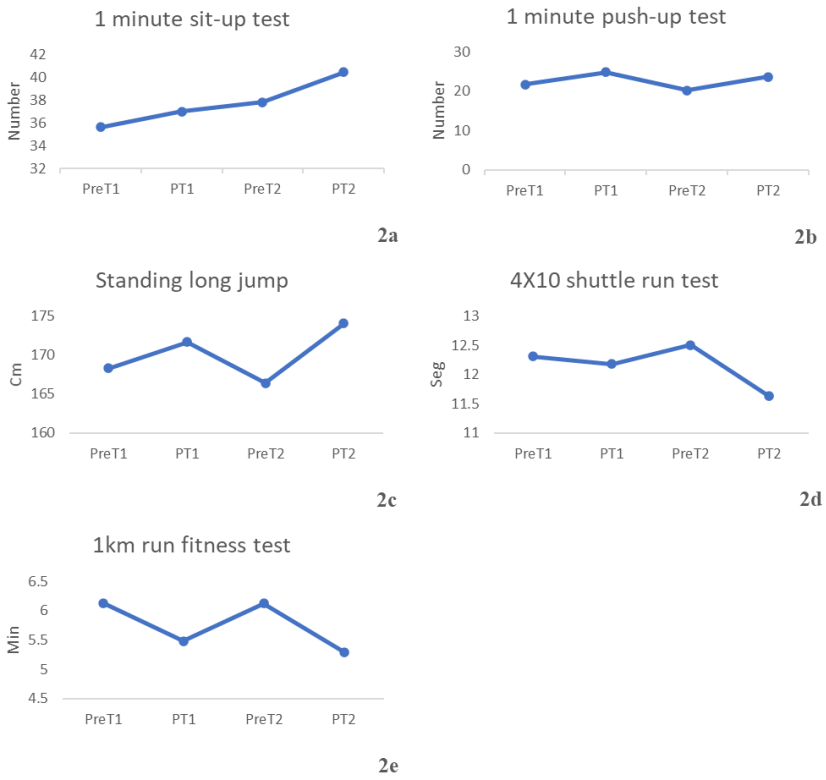

Fig. 2 Evolution of the results obtained by the participants

DISCUSSION

The results of the present study have revealed that, in untrained college-age students, the practice of individual, racket and team sports within PE courses for nine weeks generates significant physical fitness improvements. Specifically, those adaptations were attained in trunk flexors and upper body muscular endurance, lower body explosive strength, cardiorespiratory resistance, speed and agility. These results are consistent with recent studies that have verified that sports practice positively impacts physical fitness (Oliveira, Monteiro, Jácome, Afreixo, & Marques, 2017).

However, the inactivity period of nine weeks set after the intervention period 1, implied the deterioration of all fitness test results, except for the SU. Therefore, as previously observed in the sports field with detraining periods, it was verified that the adaptations attained with the PE classes are also reversible when stimulation ceases (Bosquet & Mujika, 2012). This circumstance highlights the importance of the training principle of continuity (Aceña, Díaz, González, Juárez, & Navarro, 2007).

SLJ mark deterioration on PreT2 is consistent with the study carried out by Chtourou et al. (2015). They found out that, after three weeks of detraining, it is possible to partially maintain lower body levels of explosive strength in college-aged participants. However, after five weeks, the adaptations attained deteriorated.

Bosquet and Mujika (2012) explain that both VO2max and cardiovascular endurance experience a significant deterioration during the first three or four weeks of detraining, due to the higher lactate concentration and dropped VO2max levels. This rapid loss of adaptations could explain the 1KM marks deterioration on PreT2.

SHR results deterioration on PreT2 is also consistent with previous research. Komsis and associates (2018), in one study carried out with soccer players aged between 19 and 24, verified that a 4-week detraining period resulted in a significant deterioration in speed and agility. Furthermore, it must be taken into account that both speed and agility depend on strength levels, particularly on explosive strength (Borges, 2014). And as mentioned previously, explosive strength significantly dropped after the 9-week inactivity period.

As for the SU and PU, despite both tests assessing muscular endurance, the participants were able to maintain their marks after nine weeks of inactivity in the SU but not in PU. Therefore, these results suggest that it is not clear whether nine weeks of inactivity involve the loss of all the adaptations achieved. In this respect, some studies showed contradictory results, which does not clarify this aspect. Tran and associates (2017) observed that a significant strength deterioration occurs in adolescents after a 4-week period of detraining. In contrast, Gavanda, Geisler, Quitmann, Bauhaus, and Schiffer (2020) verified that a 3-week period of detraining did not result in decreased strength and hypertrophy. Aceña and associates (2007) found in untrained participants aged between 18 and 24 that strength levels did not decay after an 8-week detraining period. Ronconia and Alvero-Cruza (2008) indicate that, in young participants, strength loss is slower than senior citizens. Another factor which could explain the lack of consistency between the SU and PU marks on the PreT2 is that obtaining good result on PU does not depends only on muscular endurance, but also on the relative strength (Alizadeh, Rayner, Mahmoud, & Behm, 2020), and perhaps this capacity has been impacted to a greater extent by inactivity.

Importantly, PT2 results were significantly better than those attained on PT1 in three tests (SU, SHR and 1KM). This circumstance suggests that some adaptations did not wholly decay. However, the mechanism whereby participants who resume PA practice after a few weeks of inactivity achieved better performance than participants who have never practiced PA is not clear. Some authors attribute this circumstance to human muscle memory, but this theory has not been confirmed in humans yet (Snijders et al., 2020).

The present study has also verified that two classes of PE per week in college-aged participants allowed them, both in the intervention period 1 and 2, to attain significant improvements in physical fitness with large effect sizes. We understand that these great improvements occurred because the participants were untrained and had a greater adaptative reserve (Aceña et al., 2007). In this regard, some studies carried out with primary and secondary students ascertained that three or more PE classes per week provide the individuals with additional benefits, which includes improved physical fitness and health, value formation and improved academic performance (Kühr et al., 2020). Unfortunately, no studies have examined this circumstance with college students. However, the World Health Organization recommendations on PA for adults aged between 18 to 64 highlight that doubling the recommended practice time (150 minutes of moderate-intensity aerobic PA during the week or 75 minutes of vigorous-intensity aerobic PA throughout the week or an equivalent combination of moderate- and vigorous-intensity activity) generates further health benefits (World Health Organization, 2013). Therefore, future research might examine whether the practice of more than two hours or sessions of PE per week generates additional benefits for college students.

Another aspect that must be taken into account is that participants in the present study were untrained individuals who did not practice either regular or structured PA. Therefore, according to the principle of progression (Roldán, 2009), it cannot be ruled out that if these participants practice PA on a regular basis, in the future, they would need a higher weekly frequency or PA volume to continue improving their physical condition, as occurs in well-trained athletes (Elvar, Donate, Medrano, Costa, & Soro, 2007).

Finally, it is necessary to mention the limitations of the study. The first one was not having included a control group. This option was not possible because the University curriculum states that all students must actively participate in PE lessons, including injured subjects, which receive curricular adaptations. Likewise, it would have been useful to have carried out, in addition to the field tests, specific laboratory tests, to determine the effects of PE practice, cessation and resumption on health.

CONCLUSION

Participating in two classes of PE per week for nine weeks improves physical fitness in untrained college students. These improvements almost entirely decay after nine weeks of inactivity, but can be recovered with another nine weeks of PE classes. Individuals who resume their PE classes after nine weeks of PE practice, followed by a nine-week inactivity period, could attain higher improvements in certain physical capacities (muscular endurance, cardiovascular endurance, speed and agility) than those participants who never exercised previously.

PRACTICAL APPLICATIONS

Integrating sport into PE curriculum activities at the university level must be considered by PE teachers for the following reasons (Rodríguez, Giménez, Abad, & Robles, 2015; Malm, Jakobsson, & Isaksson, 2019): a) Are useful to improve physical fitness; b) Promote value formation; c) Provide the PE curriculum with variety; d) They are useful in establishing lifetime habits of PA practice; and e) Promote socialization.

Moreover, since adaptations attained through the practice of PE are reversible after periods of inactivity, it is necessary to undertake awareness campaigns among college students to promote the continued and regular practice of PA when PE lessons are not provided (final exams and holidays) (Alkhateeb et al., 2019). In the case of Saudi Arabia, it is a pressing need due to the low levels of PA practice (Almutairi et al., 2018).

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FIZIČKO VASPITANJE: VEŽBANJE, PRESTANAK I NASTAVAK NEUTRENIRANIH SAUDIJSKIH STUDENATA

Cilj ove studije bio je dvojak: prvo, da se proveri da li su dva časa nedeljno fizičkog vaspitanja (FV) dovoljna za poboljšanje fizičke spremnosti studenata. Drugo, da se utvrdi efekat vežbanja, prestanka i nastavka vežbanja u okviru FV na navedene studente. Trideset (30) neutreniranih saudijskih studenata pohađalo je časove PE dva puta nedeljno tokom devet nedelja. Nakon toga, bili su neaktivni devet nedelja, i konačno, ponovo su pohađali časove PE tokom još jednog perioda od devet nedelja. Posle dva devetonedeljna perioda FV, ispitanici su poboljšali snagu, izdržljivost, brzinu i agilnost. Period neaktivnosti podrazumevao je gubitak svih adaptacija postignutih tokom prvih devet nedelja vežbanja, osim mišićne izdržljivosti mišića fleksora trupa. Dva časa nedeljnog FV tokom devet nedelja poboljšavaju fizičku spremnost neutreniranih studenata univerziteta. Ova poboljšanja gotovo u potpunosti nestaju nakon devet nedelja neaktivnosti, ali se mogu dostići sa još devet nedelja časa FV. Pojedinci koji nastave časove FV nakon devet nedelja fizičkog vaspitanja, nakon čega sledi devetonedeljni period neaktivnosti, mogli bi da ostvare veća poboljšanja u određenim fizičkim kapacitetima (mišićna izdržljivost, kardiovaskularna izdržljivost, brzina i agilnost).

Ključne reči*: fizičko vaspitanje, kontinuitet, učestalost, reverzibilnost*

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