The proceeding book of 2nd International Conference on Science and Medicine in Aquatic Sports: Split, Croatia, 19th-22nd September 2023

SMAS

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2ND INTERNATIONAL CONFERENCE ON SCIENCE AND MEDICINE IN AQUATIC SPORTS

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2nd International Conference on Science and Medicine in Aquatic Sports

PROCEEDINGS

EDITORS:

Ognjen Uljević
Nikola Prlenda
Nikola Foretić

19th-22nd September 2023.

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Radisson Blu Resort & Spa, Put Trstenika 19.

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Diagnostics Of Injuries In Water Sports

Igor Borić[1]

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ABSTRACT

In addition to the mandatory clinical examination, diagnosing an athlete's injury is based on radiological processing. Today, we have numerous radiological diagnostic methods at our disposal: radiography, computerized tomography (CT), ultrasonography (US), magnetic resonance (MR), and sometimes radiological diagnostics are supplemented with scintigraphy. Each of the mentioned methods has its own importance, i.e. it has its own advantages and disadvantages that differentiate it from other methods. The methods are mutually complementary, complementing each other in creating a final diagnosis.

Radiography is the most available radiological method and is cheap. It is ideal for analizing bone structures, but its disadvantage is the poor display of soft tissues. Also, an image of all the anatomical structures located between the X-ray tube and the film is superimposed on the radiograph, which makes it difficult to analyze individual structures. Previously, radiography was used to show intra-articular structures after intra-articular contrast agent administration, and such an examination is called arthrography. Today, arthrography has been replaced by magnetic resonance or possibly CT- or MR-arthrography.

Computed tomography (CT) is an imaging radiological method that gives us a layered view of the examined part of the body. We use ionizing - X-ray radiation to create the image. CT is suitable for good visualization of bony structures, free joint bodies, topographic relationship of bony and soft tissue structures, but it is also not the method of choice for visualization of soft tissue structures.

Today, ultrasonography (US) is a widely available method that does not use ionizing radiation, so due to its harmlessness, it is suitable for repeating the examination several times. It is simple to perform, but the interpretation of the findings is extremely dependent on the knowledge and experience of the viewer. US is suitable for showing superficial soft tissue structures, while deeper intra-articular structures are the domain of MR imaging. In the musculoskeletal system, it is suitable due to the possibility of dynamic examination of muscles and tendons, i.e. examination during contraction and relaxation. It also enables simply guided puncture.

Scintigraphic methods use radioactive isotopes, the methods are highly sensitive, but poorly specific, which is a significant drawback. Today, it is slowly being replaced by the so-called hybrid imaging methods that are a combination of nuclear medicine and radiology methods: PET/CT, PET/MR.

Magnetic resonance (MR) is a radiological imaging method that does not use ionizing radiation to produce images, but the energy of hydrogen protons. It is the optimal method of layered imaging of the musculoskeletal system: the possibility of multiplanar imaging and good contrast resolution make MR an ideal method for treating the musculoskeletal system. It is the method of choice for

displaying intra-articular structures, so it has replaced conventional arthrography in most cases. In addition to the presentation of the morphology of the organs, it also shows their function, for example the vitality of the bones. It is also the only "in vivo" method for a complete and sufficient representation of the articular cartilage, both its continuity and internal structure. It is usually followed by radiography or scintigraphy when there is a suspicion of a bone lesion, that is, it is followed by an ultrasound examination when we suspect soft tissue pathology.

When we talk about the use of magnetic resonance in the assessment of sports injuries, the high sensitivity and specificity for pathological conditions of the musculoskeletal system, and the possibility of simultaneous evaluation of injuries to several organs (which is of extreme importance in the case of combined injuries, e.g. bones, ligaments and muscles), impose this radiological painting method as the method of choice.

Which of the above diagnostic methods we will choose to display a particular injury depends on a number of factors. As it is a young person, we will try to choose a method that does not have harmful ionizing radiation. Of course, we have to take into account what kind of injury it is, that is, which structures we expect to be injured. If it is a soft tissue injury, the first place in the algorithm of radiological examinations is US. If the US does not give us enough information or if it is an injury to deeper and intra-articular structures, we will resort to magnetic resonance. If it is a bone injury, the radiograph will give us enough information for proper treatment. When it comes to complicated fractures, intra-articular fractures with possible free articular bodies or unclear dislocations, we will supplement radiological diagnostics with computerized tomography. Sometimes even CT does not give us the desired information, especially if it is a fatigue fracture or just a stress reaction of the bone, or when we are interested in the vitality of the bone fragment, the condition of the articular cartilage or the growth plate. In that case, magnetic resonance will give us the answer.

Timely and accurate diagnosis of a sports injury is important not only for the choice of optimal treatment, but also for the evaluation of the injured athlete's return to sports activity, either training or sports competition. But only the good cooperation of the clinician, who indicates the radiological examination, the radiologist, who performs the examination, will lead to the correct and purposeful use of the optimal method in diagnosing and monitoring sports injuries.

The athlete himself, his coach, physiotherapist and team doctor should be included in this cooperation in order to close the circle of successful treatment and return to sports activity.

Respiratory Muscle Function and Fatiguability in Apnea Diving – A Perspective

Joseph W Duke[1]

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ABSTRACT

Apnea, or breath-hold, diving is a popular activity that is commonly used for recreation, sustenance, and even sport. In the former two situations, the breath-hold would most likely be submaximal and disrupt physiologic homeostasis only moderately. In apnea diving as a sport there are several disciplines which can be broadly separated into static (i.e., hold one's breath under water) and dynamic (i.e., diving for depth) apnea diving. In the case of diving for sport, the apnea is likely to be maximal and elicits a substantial physiologic challenge spanning multiple physiological systems including the cardiovascular and respiratory systems.

A maximal apnea has two phases, which are referred to as the "easy-going" and "struggle" phases. The easy-going phase is a quiescent period where the glottis is closed and respiratory muscle motor output is, effectively, zero. The respiratory motor output is voluntarily suppressed, which implies that this is a behavioral response rather than a response that is innate and part of the mammalian diving reflex. As the apnea continues, the individual experiences a growing urge to breathe, which is driven by a variety of stimuli, but probably linked mostly to the increasing arterial partial pressure of carbon dioxide. At some point during the apnea the physiologic breakpoint is reached and the individual transitions to the struggle phase. During the struggle phase the glottis remains closed and the respiratory muscles begin to contract (Cross et al., 2013). The pattern of contraction can be described as "crescendoing" where the magnitude of pressure swings progressively increases for the remainder of the apnea. In essence, the individual will "struggle" for the duration of the apnea until the conventional breakpoint is reached and the individual resumes breathing.

The onset of the physiologic and conventional breakpoints is due to a variety of factors including psychogenic, humoral, or mechanical stimuli. The psychogenic factors can include dyspnea, or sensation of breathlessness, anxiety, and/or fear. The humoral factors include an increase in arterial partial pressure of CO_2 and a decrease in arterial partial pressure of O_2. In general, it is the arterial PCO_2 that drives the urge to breathe. The mechanical factors can include the tension developed and maintained by the respiratory muscles to hold the breath, which could trigger reflexes increasing the sensation of breathlessness and urge to breathe (Godfrey and Campbell, 1968). However, apnea divers can employ a variety of factors to prolong the breath-hold, i.e., force the breakpoints to happen later in the breath-hold. One such strategy is a pre-breath-hold hyperventilation. Because of the relationship between alveolar ventilation and arterial PCO_2 and PO_2, a hyperventilation prior to a breath-hold would decrease PCO_2 and increase PO_2, which would mean these parameters have further to change before the breakpoint(s) is/are met. However, too substantial of a hyperventilation could negatively impact cerebral blood flow and increase the risk of a shallow water blackout. Another strategy one could employ is glossopharyngeal insufflation, i.e., lung packing. In essence, the individual pumps or forces additional air into their lungs just prior to a maximal apnea. Previous work has suggested that this

can increase lung volume by 11-26% (Lindolm and Nyren, 2005; Loring et al., 2007; Chung et al., 2010; Walterspacher et al., 2011; Mijacika et al., 2017; Patrician et al., 2021a). Again, caution should be taken with this technique as barotrauma to the lungs is possible. Finally, an individual can pre-breathe 100% O_2 to increase arterial PO_2 and prolong the breath-hold, but this is likely not allowed in competitions.

Previous work has measured respiratory muscle pressure swings during a maximal "dry" apnea and report changes in transdiaphragmatic pressure (P_{DI}) of +30 cm H_2O and changes in expiratory muscle pressure, quantified via gastric pressure (P_{GA}) of +15 cm H_2O (Cross et al., 2013). These changes in P_{DI} are roughly equivalent to what a young healthy individual would incur during exercise at a ventilation of ~100 L/min (Molgat-Seon et al., 2018), which has been shown to lead to exercise-induced respiratory muscle fatigue. This leads one to consider whether or not respiratory muscle fatigue occurs as a consequence of a maximal apnea. The pressure-time index for the diaphragm and the expiratory muscles during a maximal breath-hold have been shown to reach their respective critical thresholds where task failure (i.e., fatigue) would occur. However, to date, no one has determined whether or not the respiratory muscles fatigue following a maximal apnea.

The consequences of respiratory muscle fatigue following a maximal apnea could include a reduction in subsequent apnea duration. Ongoing work from our lab has suggested that 30 minutes of recovery is insufficient to return respiratory muscle pressure generating ability back to pre-fatigue levels and it is unknown how much time is needed. A consequence of fatigue and a prolonged period of weakened respiratory muscles could be an "open window" period where the risk of upper respiratory tract infection is increased. This hypothesis is largely derived from the aging literature which demonstrates that the elderly have diaphragm sarcopenia that is linked to a greater incidence of upper respiratory tract infection and pneumonia (Elliott et al., 2016). However, there are a few possible strategies that apnea divers can employ to prevent or mitigate this potential consequence. First, they could perform deliberate inspiratory and/or expiratory muscle training. This could increase apnea time, reduce fatiguability, increase recovery time, and/or decrease the sensation of breathlessness during a maximal apnea. Additionally, divers could employ anti-oxidant supplementation to strengthen the immune system. To date, though, it is unknown if and how these strategies would have a positive impact.

REFERENCES

1. Cross, T.J., Breskovic, T., Sabapathy, S., Maslov, P.Z., Johnson, B.J., and Dujic, Z. Respiratory muscle pressure development during breath holding in apnea divers. *Med Sci Sports Exerc*. 45: 93-101, 2013.
2. Chung, S. C., Seccombe, L. M., Jenkins, C. R., Frater, C. J., Ridley, L. J., and Peters, M. J. Glossopharyngeal insufflation causes lung injury in trained breath-hold divers. *Respirology* 15: 813–817, 2010.
3. Elliott, J.E., Mantilla, C.B., Pabelick, C.M., Roden, A.C., and Sieck, G.C. Aging-related changes in respiratory system mechanics and morphometry in mice. *Am J Physiol Lung Cell Mol Physiol*. 311: L167-L176, 2016.
4. Godfrey, S. and Campbell, E.J. The control of breath holding. *Respir Physiol*. 5: 385-400, 1968.

5. Lindholm, P., and Nyrén, S. Studies on inspiratory and expiratory glossopharyngeal breathing in breath-hold divers employing magnetic resonance imaging and spirometry. *Eur. J. Appl. Physiol.* 94: 646–651, 2005.
6. Loring, S. H., O'Donnell, C. R., Butler, J. P., Lindholm, P., Jacobson, F., and Ferrigno, M. (2007). Transpulmonary pressures and lung mechanics with glossopharyngeal insufflation and exsufflation beyond normal lung volumes in competitive breath-hold divers. *J. Appl. Physiol.* 102: 841–846, 2007.
7. Mijacika, T., Kyhl, K., Frestad, D., Barak, O., Drvis, I., Secher, N. H., Dujic, Z., and Madsen, P.L. Effect of pulmonary hyperinflation on central blood volume: an MRI study. *Respir. Physiol. Neurobiol.* 243: 92–96, 2017.
8. Molgat-Seon, Y., Dominelli, P.B., Ramsook, A.H., Schaeffer, M.R., Romer, L.M., Road, J.D., Guenette, J.A., and Sheel, A.W. Effects of age and sex on inspiratory muscle activation patterns during exercise. *Med Sci Sports Exerc*. 50: 1882-1891, 2018.
9. Patrician, A., Gasho, C., Sprajić, B., Caldwell, H. G., Barak, O., Drvis, I., Dujic, Z., and Ainslie, P.N. Case studies in physiology: breath-hold diving beyond 100 meters – cardiopulmonary responses in world champion divers. *J. Appl. Physiol.* 130: 1345-1350, 2021.
10. Walterspacher, S., Scholz, T., Tetzlaff, K., and Sorichter, S. Breath-hold diving: respiratory function on the longer term. *Med. Sci. Sports Exerc.* 43: 1214–1219, 2011.

Freediving; Aerobic or Anaerobic Activity?

Ivan Drviš

ABSTRACT

A top freediver is primarily distinguished by the possibility of large accumulation of aerobic-anaerobic energy and the minimal pace of its consumption during apnea performance. When performing dynamic apnea, long-term breath retention in the body inevitably leads to intermittent hypoxia and increased anaerobic metabolism due to the activation of the dive response. Dive response represent a series of hemodynamic physiological changes caused by the simultaneous action of the sympathetic and parasympathetic nervous system with the aim of centralizing blood flow and saving oxygen for the metabolic needs of the brain. Considering that during a dynamic dive, the muscles can use energy from all metabolic systems, while the brain is almost exclusively dependent on the aerobic oxygen supply system, the question arises; is freediving more aerobic or anaerobic activity? Therefore, it is necessary to evaluate the relationships between specific functional aerobic-anaerobic capacites and maximal performance in dynamic apnea, and to investigate the effects of different functional training on success in achieving the maximum diving distance or depth in apnea diving.

Last 20 years, competitive freediving is marked by the rapid increase in results in all three types of freediving: at rest, at a distance, at depth. Dealing with the lack of scientific knowledge about apnea diving coaches and practitioners are in constant need for development of effective training methods. In modern competitive freediving, it is necessary to implement the same general principles and training regimes that apply in every top-level sport. This means continuous, daily work with gradual progression of load in an optimally designed, planned and programmed training process. The success of a freediver is determined by genetic predispositions, dedication to training and knowledge of effective training methods.

For applying proper training methodology, it is very important to understand where energy for apnea activity is coming from. During the apnea diving body is supplied with energy in conditions of a rapid growing lack of O_2 and increasing CO_2. It can be stated that freediving efficiency is conditioned with three factors: 1) ability to accumulate energy, 2) economy of consumption of accumulated energy or developing the “diving response”, and 3) psycho-physical tolerance of hypoxia and hypercapnia. Dive response, also called “*mammalian diving reflex*”, is innate mechanism of prolongation of apnea. It is evolutionary physiological adaptation of mammals and some birds to long-term breath holding in order to save oxygen. This reflex is the strongest in babies, it weakens with age, and becomes stronger with apnea training.

As presented previously, "centralization of blood flow" during voluntary apnea is pronounced "chemoreflex stress" (↑PpCO2 and ↓PpO2) that results in a significant increase in sympathetic nerve activity which causes peripheral vasoconstriction. The increase in sympathetic nerve activity (SNA) during apnea in trained freedivers is > 20 times compared to the basal state. Trained freedivers have, on average, an approximately 5-fold increase in SNA compared to control subjects. Prolonged, voluntary breath holding results in a significant increase in muscle SNA,

peripheral vasoconstriction, centralization of blood flow, an increase in arterial pressure and finally increased brain perfusion. As the metabolic needs of the muscles for specific work are always the same, in conditions of poor blood supply to the muscles anaerobic metabolism increases. The question is for: for how much? Several studies tried to answer it. In first study, authors try to establish differences in the extent of anaerobic glycolysis activation during monofin swimming during respiration and apnea. Double activation of anaerobic metabolism was measured in the first 100 m of DYN. In other study, conducted on 28 freedivers distribution of SpO_2 and b(LA) were measured during maximal DYN discipline. Researchers concluded that at the end of maximal DYN measures pronounced anaerobic energy production. Similarly, data were reported in study that observed effects of programmed anaerobic training on performance in DYN conducted on 26 freedivers. Study results refer to conclusion that interventions introducing anaerobic interval training resulted in a significant increase in diving distance. Overall, shorter/shallow diving distances are predominantly aerobic in nature, while further and deeper diving requires larger anaerobic capacities. Alternative anaerobic capacities largely provide additional energy for dynamic apnea. Likewise, maintaining consciousness depends on individual aerobic capacity. It can be concluded that to increase diving abilities and prolong dynamic apnea, it is necessary to develop both functional-metabolic systems.

How to Develop Swimmers from The Beginning to The Greatest Senior Level

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ABSTRACT

Swimming has a specific effect which is conditioned by the unique physical activity in the water medium through the individual actively moves. Moving through water, i.e. swimming besides saving life, positively affects health, social, psychological and economic status (Barnsley et al., 2017; Lahart & Metsios, 2018). With a minimal risk of injury (Kwaśna and Smolińska, 2016), swimming improves functional and motor skills, motor knowledge, and workability, and affects awareness of one's health from an early age as well as control of one's own body in the water environment. In children, it causes positive emotional reactions such as joy, elation, fulfillment, playfulness, and acceptance. All of these factors can contribute to why parents introduce their children to swimming and encourage them to dedicate their free time to the sport. Many of them begin their journey as non-swimmers, starting with a program that teaches the basic movement through the water. Then enroll in swimming schools, and progress from club-level competition to regional competitions, all with the aspiration of reaching elite status at international events like the European Championship, World Championship, and ultimately, the Olympic Games. During this extensive developmental journey, the desires and aspirations of swimmers, parents, and coaches often diverge. In the beginning, children simply want to play, parents hope for their children to socialize and develop physically, while coaches aim to identify potential future champions, akin to finding the next Michael Phelps. As time goes on, assuming the swimmer remains healthy, the desires and aspirations of all parties tend to align more closely, with a shared focus on achieving better results. Through this journey, coaches have to know that morphological, motoric, functional and psychological changes are the result of the growth and development of swimmers with individual differences. The process of growth and maturation is a non-linear process, and the dynamics of changes at the individual level must first be generally modeled, in order to be able to define and compare individual characteristics of swimmers (Šiljeg et al., 2023). Growth and development are directly influenced by endogenous (inheritance, gender and age) and exogenous (diet, existence of chronic diseases, social conditions, physical activity, sports and other) factors. A careful approach to the development of swimmers is possible only with knowledge of the characteristics of biological growth and development, understanding that a child is not a "little man" and that the concept of training male and female swimmers is as different as the concept of training sprinters and long-distance swimmers (Šiljeg, 2018). Besides knowing the growth and development of swimmer's coaches should be familiar with anthropometrics characteristics, motor, functional, cognitive abilities, conative and sociological characteristics, nutrition and hydration, injury prevention, technological tools, communication and coaching skills. The coach has to know the specifics of the water medium, the forces that act on the body at rest, the forces that move the body and the resistances that oppose the movement of the body. He has to know a

methodic approach to how to achieve a body position and coordination that affects the reduction of the resistance that opposes the movement of the body. Optimal body position in the water, and kinetic chain of the stroke, kick, breath and coordination of all mentioned, requires an understanding of the water medium and the trainer's imagination in creating exercises. All to reduce resistance and improve moving through the water. Deep understanding of every phase of stroke, leg kick, body rotation/undulation, breath, start and turn demanding knowledge from biomechanics. Each technique of the same length has different energy requirements, so this should be respected when learning the techniques. Understanding valuable cognition such as entropy and fractal dimension, swimming speed, speed fluctuation, stroke length, stroke frequency, stroke rate, stroke index can contribute to enhanced swimming performance and achieving their goals. Knowing the principle of programming, planning, periodizing, implementing the training and controlling the effects of the exercise process and prediction of results and physiology contribution (aerobic, aerobic/anaerobic and anaerobic) of every task and training unit, as well as distinguishing information load from muscle load and energy load can help swimmers to swim faster. So, Coach has to be “Superman” but with limited action. He does not write a diet program, does not make a medical diagnosis, and does not treat or prescribe supplements. Will a “Superman” coach like this led a swimmer to the Olympic games? “Superman” coach with his team, a talented athlete who has the possibility of training in pain, and desire for competition ad to win may lead to success. Team means having people available at every moment of the training process. Having a consistent and committed team can be crucial for swimmers' success. In the beginning, it is only the swimmer, parents and coach. The more successful the swimmer, the bigger the team needs. It is a question to think about: during a swimmer's career should a coach be an imaginative animator, biomechanist, physiologist or psychologist? Or such every development period in a swimmer's career have different demands about which coach is appropriate for children? In conclusion, we must not forget that an athlete has one career and one dream. A coach, depending on how successful his own training philosophy is based on experience, knowledge, scientific cognition, intuition, factor x and charisma can have many challenges and many successes during his career. Swimmers, parents and coaches have to be aware that practicing swimming is a long journey with great episodes and less successful moments. Swimming must be a passion and full dedication of all participants.

Long-Term Physiological and Performance Follow-Up of Olympic Champion Rowers

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ABSTRACT

Multi-year studies that describe the development of physiological and performance characteristics of endurance athletes who represent the true elites of their respective sports (i.e. Olympic and world champions) are rare. This is probably due to the limited access to such subjects and due to the finite nature of the population. This work aims to provide an insight into the multi-year development of physiological and performance characteristics of two rowers who have won multiple Olympic and world championship gold medals. The monitored period spans a total of 19 years of their competitive careers. During those 19 years the rowers were tested on a yearly basis. Over the monitored 19-year period, the rowers have won two Olympic gold medals and six world championships gold medals, in addition to a total of four silver and bronze medals won at Olympic games and world championships. The physiological and performance parameters monitored over the 19-year period were maximal oxygen uptake, maximal heart rate and maximal oxygen pulse (parameters that directly influence the maximal oxygen uptake), maximal mean power derived from ramp-wise test and the average power output sustained over 2000 and 6000-m on a rowing ergometer.

The results indicated that maximal oxygen uptake gradually increased up to about 22 years of age and leveled-off at a value of approximately 7 $l \cdot min^{-1}$ with minimal fluctuations up to about 26-27 years of age. However, the parameters that directly influence the maximal oxygen uptake changed, with the evident age-related decline in maximal heart rate while oxygen pulse, which may serve as an indirect measure of the stroke volume, correspondingly increased allowing the athletes to maintain exceptional maximal oxygen uptake values. From the ages 26-27 up to the ages 33-34 the maximal oxygen uptake decreased slightly (although it remained above 6 $l \cdot min^{-1}$ throughout the monitored period), likely because of decreased maximal oxygen pulse observed in the same time period. Maximal minute power of the studied rowers, derived each year from their ramp-wise tests, improved throughout the monitored period with the highest values observed and maintained after the ages of 29-30. The maximal minute power seems to very closely resemble the average power output sustained during the 2000-m all-out tests on a rowing ergometer. Despite the decrease in maximal oxygen uptake in later years of the follow-up, maximal minute power and performance in 2000 and 6000-m rowing ergometer tests remained consistent with minimal fluctuations up to the ages 34-35. These observations may contribute to the body of knowledge on endurance athletes representing the true elites of their respective sports.

Adolescence, Sport and Mental Health

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To be mentally healthy means a state of well-being in which an individual can cope with the normal stresses of life, work productively, maintain fulfilling relationships, and make meaningful contributions to society. It involves emotional and psychological well-being, the ability to manage emotions and thoughts, and a positive outlook on life. Being an adolescent and engaging in sports seems like a winning combination for mental health. And although there is a significant body of evidence supporting the ancient Latin proverb "Mens sana in corpore sano" (a healthy mind in a healthy body), it's not always so straightforward. This is some kind of hidden mine because one significant part of athletes are adolescents which might be vulnerable population in general as well as in regard of sport involvement. The special focus must be on sport specialisation defined as: “Sport specialization occurs when an athlete has made the decision to concentrate on a single sport for competitive purposes. While several definitions may exist, athletes are generally considered specialists if they decide to quit participating in other sports, devote at least eight months per year to the sport.” Specialization has become a popular trend within youth athletics, particularly amongst swimmers with starting age as early from 11 or 12 years.

Sociological roles of adolescence among others are

Identity Formation: Adolescence is a crucial period for identity formation, where individuals begin to explore and define their own values, beliefs, and goals, distinct from their family and childhood norms. **Peer Groups and Socialization:** Peer groups become central in influencing behavior, values, and attitudes. Adolescents start forming more complex social relationships, learning societal norms, and rules through interaction with peers. **Education:** During adolescence, individuals undergo a significant part of their formal education, which not only equips them with knowledge but also socializes them into societal norms and expectations.

Transition to Economic Independence: Adolescence is a period when individuals start acquiring skills and knowledge that would later help them in gaining economic independence.

Psychosocial roles of adolescence are:

Emotional Development: Adolescents experience a deepening of emotional understanding, empathy, and the capacity to have more complex emotional experiences. **Moral Development**: It's a time of moral development where they start understanding more complex ethical concepts and thinking critically about right and wrong. **Self-Concept and Self-Esteem**: Adolescents start developing a more differentiated self-concept and are increasingly concerned about their self-esteem. **Cognitive Development**: Adolescence is marked by significant cognitive development, involving abstract thinking, problem-solving, and the ability to plan for the future.

Autonomy: Adolescents work towards gaining autonomy, establishing independence from their parents while forging new relationships with peers and adults. **Mental Health:** The psychosocial aspects of adolescence involve navigating the stresses and pressures of this period, which can have implications for mental health. It's a period of vulnerability but also an opportunity for developing resilience and coping skills. **Sexual and Gender Identity:** Adolescence is a critical period for the exploration and understanding of one's sexual and gender identity. It is a time when individuals develop a deeper understanding of their bodies and relationships.

So, we need to be aware of significantly possible potential negative interference of sports specialization with adolescence and health like: **Increased Risk of Injury:** Specializing in a single sport can lead to an increased risk of overuse injuries due to the repetitive strain placed on specific muscle groups and joints. **Burnout:** Adolescents who specialize in a single sport may experience burnout, characterized by chronic fatigue, decreased performance, and a loss of interest in the sport due to intense, focused training over extended periods. **Limited Skill Development:** Focusing on a single sport can limit the development of varied motor skills and physical literacy that comes from participating in a range of sports. **Decreased Socialization Opportunities:** Specialization can limit socialization opportunities as adolescents spend most of their time with the same group of peers, potentially missing out on diverse social experiences that come from engaging in different activities or sports. **Academic Impact**: Intense training schedules can potentially interfere with academic performance and opportunities for educational attainment, as adolescents might prioritize sport over their studies. **Mental Health Issues**: The high pressure to perform and succeed can lead to mental health issues, including increased stress, anxiety, and depression, particularly if the adolescent perceives their self-worth mainly through their sports performance. **Loss of Enjoyment:** The pressure and intensity of specialization can sometimes lead to a loss of enjoyment in the sport, turning a fun activity into a job-like endeavour. **Narrow Identity Formation**: Adolescents might develop a narrow self-identity, tying their self-esteem and self-worth primarily to their success in the sport, which can be problematic if they face setbacks or have to retire due to injuries. **Financial Strain:** Sports specialization can often be costly, putting a financial strain on families due to expenses such as coaching fees, equipment, and travel for competitions. **Reduced Free Play:** Specialized athletes may have less time for unstructured free play, which is essential for cognitive and social development.

The trend toward early sport specialization is likely motivated in large part by the expectation that it will increase the likelihood of long-term athletic success. However, recent studies suggest that the majority of elite athletes delay specialization at least until mid to late adolescence. It is essential to consider the developmental psychology of children and adolescents and to avoid imposing expectations that are beyond their neurocognitive capabilities. In addition to depression, anxiety, and burnout, young athletes who are pressured to perform to excessively high standards are likely to internalize athletic failures as feelings of shame. This can lead to maladaptive perfectionistic traits and potentially overtraining, clinical eating disorders, or other harmful behaviours that will result in declines in performance, physical health, and overall wellbeing.

Adolescence is a challenging developmental period, and involvement in competitive sports, with all the pressures it carries starts in this age range and can negatively interfere with normal and expected development. Recent investigations show that athletes are not immune to mental illness despite outward appearances of strength and wellness. So medical and sport professionals across all specialties and disciplines must be aware of the psychiatric comorbidities in athletes and even direct influence of sport on expression and outcome of mental disorders. Further work is needed to better inform sport-specific recommendations regarding sport specialization and to optimize the beneficial effects of sport participation while limiting the risks of harm.

ABSTRACTS

Surgical Repair of Acute Distal Biceps Tendon Rupture: Our Experience with Emphasis on Sailing Injuries

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ABSTRACT

INTRODUCTION: Distal biceps tendon (DBT) ruptures are relatively rare injuries, mostly among middle aged men, during sports activities or manual labor. In acute DBT rupture with high demanding patients, surgery is a method of choice. Two most represented surgical methods are one incision and two incision technique, combined with various bone-tendon fixation techniques. We did retrospective study of operated patients with acute DBT rupture in our institution during last two years with emphasis on injuries during sailing. **METHODS:** During period from May 2021 to May 2023 we surgically treated 12 patients with acute DBT rupture. In all of these cases we used one incision technique with reinsertion of tendon using cortical button and interference screw (BicepsButton, Arthrex). All patients had postoperatively hinged elbow brace during 6 weeks with 2 weeks only passive movements, and next 4 weeks active flexion with restrictions. We observed injury mechanism, time to operation, functional outcomes, complications and return to work or sports activities after surgery. **RESULTS:** We treated 12 male patients average age 42 years (min. 30, max. 55). 3 patients (25%) had sailing related injuries (one resulting from fall, two during eccentric contraction), 3 patients (25%) had sports related injuries (2 weightlifting, 1 boxing), 5 patients (42%) occupational injuries (while carrying load), and one injured in traffic accident. Average time from injury to operation was 12 days (min. 4, max. 21). ROM and strength were satisfactory for 11 patients. We observed one patient with limited extension (12°). We didn't observe any wound infections, reruptures or sinostosis. We observed 1 heterotopic ossification without functional impairment, and one transitory neural praxia (LACN). All operated patients returned to daily activities after 2 months. Return to work and sports was after 3-4 months period. **DISCUSSION:** In our department DTB injuries related to sailing contain 25% of all treated cases, which is result of Dalmatia being popular sailing region. In high demanding patients, our choice of early surgery, single incision surgical technique, tendon fixation methods and postoperative rehabilitation protocol with hinged elbow brace, provided us functional outcomes, complication rates and time to return to preinjury activities similar as in other studies of this type. **CONCLUSIONS:** In high demanding group of patient's early diagnosis of DTB rupture combined with early surgery, provides good functional outcome with low complications incidence.

Keywords: distal biceps tendon, tendon injury, biceps button, single incision, sailing injury

Scoliosis

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ABSTRACT

INTRODUCTION: Adolescent idiopathic scoliosis can be defined as complex three-dimensional spine and trunk deformity which appears in healthy children, and depending on multiple factors can progress during one of the periods of rapid growth or later in life. Along the lateral bend in the frontal plane, it includes rotation in transversal and profile change in the sagittal plane when Cobb's angle is >10°. we can divide scoliosis into structural and functional. Structural - changes in bone structures, three-dimensional spinal deformity. Non-structural or functional - lateral bend in the frontal plane, for example antalgic posture in lumboischialgia. Idiopathic scoliosis accounts for up to 80% of all scoliosis, and up to 10% require treatment. The most common are idiopathic adolescent scoliosis that occurs in about 2-4% of adolescents. Scoliosis is 3.5 times more common in women. The occurrence of scoliosis is more common in families, so it is important to take a family history and examine siblings. The reasons why we treat scoliosis are dorsalgia, aesthetic and impact on lung function. Swimming and water sports have been proven to help correct spinal deformities, and are therefore the first choice when recommending sports activities for patients with scoliosis. Their primary role is to strengthen the back muscles and correct posture. **DIAGNOSTIC METHODS:** The screening test for scoliosis is the Adam forward bend test, which helps us to suspect that a person has scoliosis. The gold standard for diagnosis is standing X-ray AP and LL where we measure Cobb's angle and Risser's sign. However, screening is not perfect. 9% of children with "true scoliosis" (Cobb angle of 15-36°) first came to the specialist late - at the age of 15-18. The goal of screening is early recognition and treatment of high-risk population with no symptoms developed yet. Formetric is a device used for monitoring scoliosis that gives us insight into the surface topography. The measurement system was developed for fast, non-contact and non-radiative static and dynamic measurement of the back surface and vertebrae. It is not suitable for determining diagnosis because of deviation from Cobb's angle. **TREATMENT AND CONCLUSIONS:** Treatment of scoliosis is a team effort of several different specialists. 10% of patients require conservative treatment (orthoses, physical therapy), while operative treatment is needed in 0.1-0.3% of children. The goal of therapy is to correct muscle imbalances, posture, and to slow down or stop the progression of the deformity. Indications for orthosis application are: Cobb's angle greater than 20°, confirmed bend progression of more than 5° between two X-ray images, growth potential present - Risser's sign <4. Application of orthosis (18/24 h, 23/24 h) is always combined with physical therapy. Orthoses are mostly effective in maintaining the initial bend in scoliosis under 40°. Schroth exercises are used for stable

postural correction, internal volume control techniques, and muscle activation and integration. The Cheneau orthosis is the gold standard of orthotic treatment for scoliosis. It is made as a mirror image of scoliosis. Operative correction of scoliosis is the last option in treatment and is used only for large scoliosis (Cobb's angle 45-50° and higher). To sum up the fight against spinal deformities is uncertain and demanding from several aspects. Early detection and intervention can provide great results in the treatment if the motor skills and motivation of the patient is in positive correlation with a well-educated medical team which treats him. Doctor is responsible for screening tests, diagnostics, decision on the type of treatment, monitoring the development of the deformity, verification of orthosis design and evaluation of treatment results.

Knee Injuries in Waterpolo

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ABSTRACT

INTRODUCTION: In recent years there has been a notable increase in the number and percentage of knee injuries amongst athletes during the Olympic games in Beijing in 2008, in compare to the Olympic games in Rio de Janeiro in 2016. There has been a reported higher percentage of acute injuries (73,4 %) in compare to those that were reported chronic (20,5 %). Amongst all injuries in waterpolo, knee injuries were present in 8,3% of all cases and the most occuring one being the pain caused by the enthensitis of the medial collateral ligament, also called „Swimmer's knee ". **ANATOMY OF THE KNEE:** The knee joint is the largest joint in the body, made up of 3 bones – femur, patella and tibia, as well as of two joints – tibiofemoral and patellofemoral. It allows the movements of flexion and extension, as well as a small range of medial and lateral rotation. We divide the ligaments of the knee in the collateral ones (medial and lateral) and the cruciate ones (anterior and posterior). Also, the lateral and medial menisci which have a role in stabilizing the knee and in assisting the knee joint in weight distribution, shock absorbance and increasing the area of contact. **KNEE INJURIES:** Meniscal injuries occur when flexion or extension are performed with fixated internal or external rotation of the lower leg. One of the most common meniscal injuries is the bucket handle meniscus tear, in which a tear forms in the center of a meniscus while the end parts of the meniscus are still attached to the knee joint and the outer edge remains curved, resembling a handle on a bucket. Choices of treatment are partial meniscectomy or repair with sutures along with physical rehabilitation. Anterior cruciate ligament injuries are the most common injuries of the knee joint, usually caused by the hyperextension or the back movement of the femur once the lower leg is flexed and fixated to the ground. In these cases, bones of the leg twist in opposite directions under full body weight. Lachmann test and Front drawer test have a high sensitivity for diagnosing these types of injuries. Treatment in athletes and patients under the age of 40 is surgical (arthroscopical approach). For other candidates recommended is conservative treatment, which includes resting and strengthening the muscles of the upper leg for better knee join stability. Posterior cruciate ligament injuries are caused due to the backward switch of tibial condyle when the lower legi s flexed. Iti s a relatively rare injury. Posterior drawer test is a very important diagnostical test in such cases. Treatment of choice would be surgery. Lateral collateral ligament injuries are caused due to excessive adduction or internal rotation of the lower leg. Occurs less frequent than medial collateral ligament injuries. Treatment of choice would be surgery with a postoperative usage of crutches for eight weeks and later on physical rehabilitation. Medial collateral ligament injuries are caused due to excessive abduction or internal rotation of the lower leg. Complete rupture can be seen often joined with the injury of anterior cruciate ligament and medial meniscus. Along with the injury, hemarthrosis can also

appear. Diagnostic tools are ultrasound and magnetic resonance. **TREATMENT OF MEDIAL COLLATERAL LIGAMENT INJURIES:** Medial collateral ligament injuries of first and second degree are treated conservatively with the usage of orthosis along with physical therapy. For those of first-degree injuries, load bearing according to tolerance of pain with assistance if needed. Functional corset is given for protective reasons 3-4 weeks after injury. Active exercises for achieving full range of motion, as well as exercises for muscle strengthening, proprioception exercises and finally return to full activity once the strength of the injured side becomes equal to the one on the opposite side. For those of second-degree injuries conservative treatment includes load bearing according to tolerance of pain with assistance if needed. Functional corset is given for protective reasons 4-6 weeks after injury. Active exercises for achieving full range of motion, performed to the point of painful reaction. Also recommended is electrical stimulation of the surrounding muscles, isometric exercises, strengthening of upper leg muscles, proprioception exercises and finally returning to full activity once the strength of injured side is equal to the one on the opposite side. For those of third-degree injuries short term immobilization is required for tissue recovery. The rehabilitation phase in this degree of injuries is divided into four phases throughout 12 weeks. From week 1 to 3: in the first 7-10 days immobilization in tutor orthosis, after which immobilization is opened up and passive exercises with the assistance of a therapist begin for as much as 3-4 times a day or instead of therapist kinetech can be used as well. Recommended are isometric exercises. Physical therapy will include treatments with cryotherapy and later on electrostimulation of muscles. From week 4 to 6: wearing a functional orthosis, load bearing while walking should be increased for 25% every week, gradually switching to walking without crutches on the 6th week with high attention of preserving the ligaments and avoiding any unpleasant and unwanted movements. From week 7 to 9: walk and range of motion should be as full and as normal as possible, neccessary to strengthen lower extremities, perform cardiovascular training, balance exercises and proprioception exercises. From week 10 to 12: return to full activity and full range of motion without any difficulties or symptoms, running in a straight line and later in changes of direction, and finally start with sport specific training. **SWIMMER'S KNEE:** occurs most commonly in breaststroke swimmers. Considered that the feeling of pain is caused by the enthesitis of medial collateral ligament, most probably due to frequent movements of the knee into the valgus position and overstretching of the medial collateral ligament. Usually occurs on both sides. Higher risk in decreased internal hip rotation, weakness of hip rotators and quadriceps muscles. Presents with symptoms of pain in medial part of knee, dull pain present even without load bearing, feeling of tension in knee, decreased level of performance, sometimes redness and swelling in knee area. Better results of treatment when diagnosed as soon as possible. Treatment includes resting, pain control and lowering inflammatory response (with cryotherapy, NSAIDs, TENS), electrotherapeutic procedures (ultrasound, interferon currents, magnetotherapy, laser therapy), kinesitherapy, acupuncture and friction massage. **CONCLUSION**: Knee injuries are increasing in all sports, including water sports. MCL injuries and MCL entensitis are the most common in swimmers. Physical therapy and rehabilitation play an important role in the treatment of the above-mentioned injuries. The rehabilitation team is multidisciplinary and the therapy takes place step by step following the time norm and goal. Only a coordinated multidisciplinary team is a guarantee of successful rehabilitation and enables a quick return to sports activities.

Complex Regional Pain Syndrome (Crps)

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ABSTRACT

INTRODUCTION: A condition of the extremities known as complex regional pain syndrome, or CRPS, is characterized by localized pain that is inconsistent with the typical course of any known trauma or other lesion in terms of timing or intensity. The pain usually includes a distal prevalence of aberrant sensory, motor, sudomotor, vasomotor, and/or trophic abnormalities and is not localized to a particular nerve area or dermatome. CRPS appears more commonly in females than in males. The most frequent inciting events for CRPS are fractures and soft tissue injuries. **PATHOPHYSIOLOGY:** There is no recognized cause for CRPS. The peripheral and central neurological systems are thought to be involved, along with traditional inflammation, neurogenic inflammation, and maladaptive alterations in pain perception. **SYMPTOMS:** The most noticeable CRPS symptom is pain. Although it may occasionally be superficial, the pain associated with CRPS is typically described as a searing, stinging, or tearing feeling that is felt deep inside the affected limb. In CRPS, many sensory impairments are frequent. On examination, some patients display signs of hyperalgesia, allodynia, or hypesthesia. Differences in skin temperature, skin color, sweat, or edema (comparing the affected with the unaffected side) are common symptoms of CRPS. **DIAGNOSING:** There still is no golden standard for diagnosing CRPS. But still, several criteria have been found useful in easening the diagnosis. The Budapest consensus criteria is used for the clinical diagnosis of CRPS. In patients with CRPS who have active bone resorption, triple-phase bone scintigraphy is beneficial for identifying changes in bone metabolism. Plain radiographs often demonstrate patchy osteoporosis, but the sensitivity of this finding for CRPS is very low. The quantitative sudomotor axon reflex test (QSART), the resting sweat output test (RSO), and the resting skin temperature test (RST) have all been used to assess patients with suspected CRPS. **STAGING:** We divide CRPS into three phases. Acute or exudative phase, lasts from 1 to 3 months, characterized with progressive pain that can be provoked with movement or can appear spontaneous, redness, swelling, hyperhidrosis, hypertrichosis, increased nail growth, gradual functional and mobility loss. Stage 2 or dystrophic phase, lasts from 3 to 6 months, is characterized with severe pain and swelling that cannot resolve with elevation of the affected limb. Redness of the skin appears to fade, becoming paler and finally cyanotic. Skin becomes drier and along with the subcutaneous tissue it will start to atrophy and starts to appear as does the skin in patients with scleroderma. By the end of stage 2 the joint capsule becomes fibrotic and often stiffens the fingers in a flexed position. Stage 3 or atrophic phase lasts up to several years, during which the swelling disappears and leaves the skin to be shiny, pale, dry, cold, and atrophic. This is also the stage in which contractures and deformities may appear and functional deficits develop.

TREATMENT AND CONCLUSIONS: Treating patients with CRPS is often a very complex procedure with often not so successful results, mostly because of diagnosing it too late. When treating patients, we use farmacotherapy, physical therapy, blocking the regional simpatical innervation, psychotherapy and neuromodulation.

Differences Between Freediving Disciplines in Local Muscle Oxygenation, Heart Rate and Blood Parameters

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ABSTRACT

INTRODUCTION: This study aimed to determine the differences between freediving disciplines used during training. **METHODS:** The sample consisted of one 40-year-old amateur diver, with 6 years of training experience, that was monitored during 5 different diving disciplines used in diving training (static, bifin, dynamic no fins, dynamic no fins with snorkel, monofin, and sneaking). Variables that were measured are local muscle oxygenation in the vastus lateralis right and gastrocnemius right muscle. (desaturation and saturation slope), heart rate (heart rate average, heart rate drop), blood lactate accumulation, hemoglobin, and hematocrit. Descriptive statistics were calculated for all measured variables. **RESULTS and DISCUSSION:** Results showed that bifin elicited the highest heart rate (85.96 bpm), whereas the lowest values were found in sneaking (55.72 bpm). Also, the highest hemoglobin (18.8 g/dl) and hematocrit (56.4 %) were perceived during bifin, and lactates in dynamic no fins (7.7 mmol/L). Furthermore, desaturation (-0.88 %/s) and saturation (0.76 %/s) slope is highest in bifin discipline, and lowest during dynamic no fins with snorkel (-0.16 %/s; 0.20 %/s, respectively). **CONCLUSIONS:** The results showed different elicitation of measured variables in regard to the discipline.

Keywords: MOXY monitor, lactate, hematocrit, hemoglobin

Differences Between Diving Variables of Amateur Spearfishing and Freediving Activity

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ABSTRACT

INTRODUCTION: The present case study examined activity parameters of amateur diver during one spearfishing and freediving training season. **METHODS:** The sample consisted of one 42-year old amateur diver that was monitored for total 27 spearfishing (SF) and 38 freediving (FD) sessions. Descriptive statistic and t-test were calculated. Physical activity and physical measures were assessed with Garmin Descent Mk1 watch-sized dive computer. **RESULTS and DISCUSSION:** Results showed that SF is significantly different than FD in all measured variables. Specifically, during SF diver has 22.73 min longer apnea and 110,68 min surface time, and 26,99 more dives during training session. Also, SF training induces lover maximal (-14,29) and average heart rate than FD (-6,54). **CONCLUSIONS:** The results imply specificity of amateur spearfishing and freediving activity.

Keywords: apnea, heart rate, temperature, calories, divers, training load

Comparison Between General Population and Breath Hold Divers in Big Five Personality Traits

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ABSTRACT

INTRODUCTION: Psychological characteristics are essential factors in freediving as in sports in general. Due to a lack of studies, the personal traits of freedivers need to be established. The main objective of this study was to identify possible differences in personality traits between divers and recreational athletes. **METHODS:** The sample of this study included 26 participants (13 divers; and 13 non-divers; all >18 years). Data were collected through the IPIP Big Five personality test, utilizing variables of five personality dimensions (Openness to experience, Conscientiousness, Agreeableness, Extraversion, and Emotional Stability). A self-reported questionnaire consisted of fifty items which were rated by the 5-point Likert scale. **RESULTS and DISCUSSION:** The results indicated that there was no significant difference between the observed groups. Additionally, BHD athletes reported higher values in factors Extraversion (33.85±4.24), Conscientiousness (40.62±6.06), Emotional stability (38.15±5.77), and Openness (40.00±5.21) than the general population (33.46±4.61; 37.85±5.70; 36.92±7.34; 38.46±4.98, respectively). Oppositely, factor Agreeableness was higher in the general population (40.77±4.64), than in BHD athletes (39.92±4.35). **CONCLUSIONS:** The findings of this study can be observed through the complex nature of diving. Accordingly, higher values in Conscientiousness and Emotional stability can indicate that divers are more disciplined and have restricted training regimes. Furthermore, their interest in extreme activity can be explained by the higher values in the factor Openness. Even doe there are no significant differences between the groups it can be seen that BHD athletes scored slightly higher in some personality traits. Future research should focus on including a higher number of participants and observing possible differences in diving disciplines (e.g., spearfishing, freediving).

Keywords: Extraversion, Conscientiousness, Emotional stability, Openness, Agreeableness

Motor Control Differences Between Free-Divers and Spear-Fisherman

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ABSTRACT

INTRODUCTION: The aim of this study was to compare the differences in motor control abilities and mobility between professional free-divers (FD, n=10) and amateurs who mostly do spear-fishing (SF, n=10). **METHODS:** Participants, all men, (mean age = 38.05) were individually subjected to four tests of motor control abilities (postural stability and dynamic balance test on Biodex, counter movement jump and 15 second vertical jumping test on Optojump platform) and seven mobility tests (plantarflexion of left and right ankle, internal and external rotation of left and right glenohumeral joint and toe touch test). Prior to testing; age, height, weight and % of body fat was determined for each participant. K – S test for testing normality showed normal distribution for all variables so t – test for nondependent samples was used. **RESULTS and DISCUSSION:** After statistical analysis results show that although age between these two groups was not significantly different, years *spent in training* was; SF (mean = 15.9), while FD (mean = 6.8). Results show better mobility of the ankle joint was in FD (mean right = 66.500; mean left = 64.889) then in SF (mean right = 56.800; mean left = 57.100). FD group showed better results in both vertical jumping test procedures, but statistical significance was not achieved ($0.05 < p < 0.07$). Also, body composition, glenohumeral joint mobility and balance tests exhibited no differences between groups. **CONCLUSION:** These findings suggest that frequency of swimming sessions, with and without flippers, impact ankle mobility more than total time spent swimming throughout one´s career.

Keywords: balance, explosive power, mobility, underwater swimming, apnea

Differences in Motor and Functional Abilities and Morphological Characteristics in Young Water Polo Players and Swimmers

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ABSTRACT

INTRODUCTION: This study included the testing of swimmers and water polo players of younger age categories in different motor and functional abilities and morphological characteristics. The aim was to determine the differences in the functional and motor abilities of water polo players and swimmers of younger age categories. **METHODS:** The sample of participants consisted of 15 water polo players and 11 swimmers from Water polo and swimming clubs in Zadar. The sample of variables consisted of anthropometric measurements (body height, body mass, sitting height) and variables of motor and functional abilities (swimming 25 meters, swimming 50 meters, swimming 100 meters, swimming 400 meters, standing long jump, sitting medicine ball throw, chin up hold, plank, pull-ups, push-ups, wall sit hold). **RESULTS:** The results showed significant differences in the variables: body height ($p>0.00$), body mass ($p>0.00$), sitting height ($p>0.02$), swimming 25 meters ($p>0.01$) and sitting medicine ball throw ($p>0.00$), all in favor of water polo players. **DISCUSSION:** Results have shown that water polo players of the same age as swimmers in Zadar are taller, heavier and stronger. Surprisingly they also have better results in swimming tests which could be because they trained in swimming before switching to water polo. **CONCLUSIONS:** The young water polo players of the city of Zadar are more developed in anthropometrical characteristics and motor and functional abilities. Future research should include more participants from different clubs to see if these differences are unusual or normal in developmental age.

Keywords: Swimming, Water polo, functional abilities, anthropometrical characteristics, developmental age

Prediction of Senior-Age Competitive Level on The Basis of Junior-Age Anthropometric Status; 10-Year Prospective Study in Male Water Polo Players

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ABSTRACT

INTRODUCTION: There is a limited knowledge on factors which define long-term success in water polo. The aim of this research was to evaluate anthropometric indices important for a long-term success in male water polo players. **METHODS:** The study comprised 85 water polo players from Croatia and Montenegro who were tested on a set of anthropometric characteristics in their junior age (< 18 years), and then prospectively observed over the ten-year period for their senior-level-achievement. The predictors were anthropometric indices (body height, mass, BMI, sum of four skinfolds, arm and leg circumferences, diameters of the knee and elbow. Criterion was competitive achievement (top-level-achievement; medium-level-achievement; low-level-achievement). Set of multinomial regression analyses were applied for total sample, and separately for centers, and perimeter players. **RESULTS:** For total sample, analyses evidenced greater likelihood of high level-achievement in senior-age, for players who were taller (OR = 1.434, 95%CI: 1.22-1.67) and had lower sum of four skinfolds (OR = 0.90, 95%CI: 0.85-0.95) in their junior age. No significant associations were found between anthropometrics and senior-level achievement when position-specific analyses were done. **DISCUSSION:** The study revealed a relatively low influence of anthropometrics on competitive achievement in water polo, which was at least partially the consequence of the highly competitive level of tested players when they were in junior age **CONCLUSIONS:** Further studies are needed with the special emphasiz on body composition indices and among females.

Keywords: anthropometrics, predictors, regression, males, competitive achievement

Does Sport-Specific Water Polo Polygon Correlate with The Golden Standard of Anaerobic Test?

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ABSTRACT

INTRODUCTION: This study aimed to determine the correlations between sport-specific polygon in water polo and Wingate anaerobic test, in the original and arm crank version. **METHODS:** The sample of participants included 9 junior water polo players (average age 16.70±1.06 years; body height 186.11±6.42 cm; body mass 81.18±7.30 kg; body fat percentage 14.14±2.95). Used variables were measured in resting state and in polygon (average force during 20 sec, shooting velocity, and 20-meter sprint). Also, the Z-value was calculated to determine the overall result in the polygon. Wingate test variables included: Peak power (PP), average power (AP), and Power drop (PD), in both the original and arm crank version. **RESULTS and DISCUSSION:** The analysis of the results showed that there are no significant correlations obtained between any of the measured variables and Wingate tests, except for the Z-value and power drop in the original version (0.79). This correlation could be observed in the manner that players who score higher in polygon have a much higher difference between maximal and minimal power during Wingate. **CONCLUSIONS:** The results imply that the Wingate test as fully anaerobic, is not a precise measurement tool to determine the performance of water polo players. This is due to the fact that water polo is a highly complex activity and it needs a much different approach for better assessment of the athlete's performance. A polygon like this one can be a good predictor of sport-specific performance, especially for complex sports such as water polo. Furthermore, the differences between variables in rest and in polygon indicate that it is exhaustive and can mimic one complex of defense to offense in a water polo match.

Keywords: Wingate test, anaerobic capacity, junior players

Race-Induced Changes in Some of The Blood Markers in Young Male Rowers

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ABSTRACT

INTRODUCTION: Rowing is a sport discipline in which cardiovascular, energetic, and metabolic system of the athlete are heavily taxed. The main aim of this investigation was to determine the dynamics and the magnitude of change of the blood markers at the baseline, and prior and after the 6000 m race on rowing machine. **METHODS:** The participants enrolled in the study were 11 male rowers, aged 17 to 22. The testing procedure consisted of a standardized 15-minute warm-up and the 6000 m race on the Concept 2 rower. Blood samples were collected from all the participants on 3 occasions: immediately upon arrival, after the 15-minute warm-up and after the cessation of the 6000 m race. Levels of the blood lactate, glucose and hemoglobin and hematocrit were measured/analyzed as an indicator of the energetic and metabolic cost. ANOVA for repeated measures was used to determine the changes in blood markers. Additionally, effect size was used to establish the magnitude of difference in the blood biomarker levels pre-, during, and post- test. **RESULTS:** Lactate and glucose levels were significantly higher post- test ($p<0.001$, $\eta2=0.95$ and $p<0.001$, $\eta2=0.83$, respectively), while there was no observed difference in the initial, pre-, and post- test hemoglobin and hematocrit levels ($p=0.77$, $\eta2=0.028$). **DISCUSSION:** Blood glucose and lactate are shown to reach maximal values after the cessation of the 6000 m race. Towards the end of the race athletes tend to go all-out, thus fully depleting glycogen stores and consequently reaching maximal blood lactate concentrations. Since carbohydrates are known to be the main energy source during the 6000 m ergometer rowing, it came as no surprise that the highest glucose availability occurred immediately upon the end of the test. **CONCLUSIONS:** High carbohydrate diet, especially in the pre-competition period, is necessary for the optimal performance in the sport of rowing. Future studies should enroll larger sample as well as include measures of the blood markers during regular 2000 m race on rowing machine.

Keywords: male, rowers, 6000 m test, lactate, glucose

Body Mass and Lower Body Strength Are Associated with Performance of The Wingate Rowing Test in Female College Students

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ABSTRACT

INTRODUCTION: The Wingate 30-s anaerobic test (WAnT) is a widely used and reliable method for assessment of the anaerobic power during maximal ergometer exercise. Since rowing is highly dependent on the anaerobic power of the individual, the main aim of the study is to determine which morphologic, motoric, and functional characteristics are associated with the performance of the WAnT. **METHODS:** 8 female students of the Faculty of Kinesiology of the University of Split formed a sample in this study. The testing battery included 15 predictor variables (body mass and body height, push-ups, crunches, pull-ups, box squat on right leg, box squat on left leg, Sorensen test, plank hold, counter-movement jump, squat jump, drop jump, 15 seconds consecutive jumps, New Zealand anaerobic rugby test, and YO-YO test) and the result of WAnT on the rowing machine. Pearson product-moment correlation was used to establish relation between predictor variables and the performance on the WAnT. **RESULTS:** Body mass (r=0,73) and box squat on the right leg (r=-0,72) were the only two significant predictors of performance of the WAnT. **DISCUSSION:** As suggested in previous studies, body mass was found to be the most significant factor that contributes to the performance of the WAnT. Further, unilateral lower body strength, more specifically muscle endurance level, seems to have a negative impact on the performance of the WAnT. It is possible these female students have less developed fast twitch fibers much needed for the execution of the all-out/maximal bout. **CONCLUSIONS:** The anaerobic power production on WAnT test is highly positively influenced by body mass, while strength endurance in the population of female collegiate students seems to have a negative effect. Future research should include more participants and examine in more detail the differences in the body composition and the absolute and relative strength levels of female students.

Keywords: female, college students, Wingate test, rowing, body mass

Different Influence of Strength and Power Training on Performance At 2000m Rowing Ergometer Test. What Should Come First?

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ABSTRACT

INTRODUCTION: Rowing is an Olympic sport performed on water surfaces, with high physical demands mainly put on the cardiovascular, skeletal, and muscular systems. In addition, rowers aim to develop abilities related to the mentioned systems such as aerobic and anaerobic endurance, strength, power and others. The aim of this study was to determine the association of strength and power parameters with performance at a simulated 2000m rowing race in adult rowing amateurs. -**METHODS:** Participants in this study were male students at the Faculty of Kinesiology in Split, Croatia (N=12). Variables included a set of predictors consisting of 7 strength (push up, sit up, pull up, left single leg squat, right single leg squat, Sorensen hold test, plank hold test) and 4 power (countermovement jump, squat jump, drop jump, and repetitive countermovement jump test) variables. A simulated rowing ergometer race (ERG2000) result was used as a criterion. Correlation analysis was conducted for predictor variables, followed by multiple regression analyses where highly correlated predictors were excluded. **RESULTS:** Selected predictors (push-up, plank, squat jump, Sorensen hold and sit-ups) explained 57% of the variance for the ERG2000, with the Sorensen hold test (b* = -0,93) identified as the single most significant predictor. **DISCUSSION:** With the Sorensen hold test being the highlighted predictor variable, we can assume that the static strength of the posterior chain plays a great role in rowing performance. This can be explained by the nature of the rowing race which counts around 200 rowing strokes. The intensity of each stroke depends on the hip extension, executed by mentioned muscle groups. **CONCLUSIONS:** The results indicated that static strength of the posterior chain muscle groups highly determines the outcome of the 2000m rowing ergometer race and should be practically applied across different aspects of rowing training. Power training should not be neglected but dosed because it can help rowers gain an advantage at the beginning of the race.

Keywords: Rowing, ergometer, strength, power, correlation, multiple regression

Dynamic Responses of Salivary Cortisol and A-Amylase Enzyme to Rowing 6000m Race Performed on Ergometer

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ABSTRACT

INTRODUCTION: Rowing is an Olympic sport performed on water surfaces, characterized by specific cyclic movement which is repeated during the rowing race. High intensity racing puts both physical and physiological stress on the athletes. The aim of this study was to determine dynamic hormonal responses of salivary cortisol and alpha amylase enzyme, as measure of stress during simulated 6000m rowing race performed on rowing ergometer. **METHODS:** Participants in this study were male junior and senior level rowers of HVK Gusar Split competing both on club and international level (N=12). Variables included 3 cortisol related measurements, as well as 3 a-amylase related measurements (baseline level, post warm up level and post-race level) conducted using oral swabs. ANOVA tests for repeated measures were used to determine possible differences in levels of mentioned parameters at different time points of the procedure. **RESULTS:** Results showed similar development patterns in both measured variables. There was a slight, but not significant decrease in cortisol as well as in a-amylase levels from baseline to post warm up point. This was followed by a significant cortisol (p=0,001, partial eta squared=0,548) as well as an alpha amylase (p=0,000, partial eta squared=0,583) increase to the post-race point. **DISCUSSION:** Similar development patterns mentioned previously could be explained through the nature and function of cortisol and a-amylase. Both molecules highly respond to stress and have a role in moderating human metabolism. If we consider rowing race warm up being mostly aerobic with low to moderate average intensity, slight drop of cortisol and a-amylase levels should not be a surprise. Aerobic work is considered to have positive and regenerating effects on the body which is manifested through these measures as well. On the other hand, rowing race generates much higher stress putting athletes in anaerobic working zones at certain points of the race, and much closer to lactate threshold on average. This is followed by a significant increase of the catabolic hormones and enzymes including cortisol and a-amylase, trying to provide an energy response. **CONCLUSIONS:** The results indicated significant increase of cortisol and alpha amylase enzyme related to high intensity rowing. This should be practically applied in balancing high versus low intensity rowing and escaping overtraining. Further studies should include some parameters of cognitive psychology such as self-confidence and anxiety, researching their potential influence on hormonal and enzyme status through physical activity.

Keywords: Stress, rowing ergometer, alpha amylase, cortisol, analysis of variance

Entrepreneurial Project for Development of Sailing Services

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ABSTRACT

INTRODUCTION: Nautical tourism is an important sector in Croatia (Bartoluci and Sundji, 2021), which can generate substantial opportunities for economic growth. To achieve this, entrepreneurial projects in this field need to be profitable. This study aims to present an entrepreneurial project for development of sailing services, capitalizing on the industry's potential and Pula's strategic advantages for development of nautical tourism. **METHODS:** This research employs a comprehensive financial analysis (Bartoluci and Škorić, 2009) to scrutinize the intricate financial aspects associated with launching a sailing-focused service. The analysis covers initial capital requirements, administrative costs, operational expenses, and personnel salaries. Additionally, a SWOT analysis assesses the project's strengths, weaknesses, opportunities, and threats. Financial projections over five years are provided, encompassing both peak and off-peak seasons, shedding light on the projected investment return period. **RESULTS**: Analysis forecasts rapid profitability (Orešnik, 2023), with the venture turning net-positive in its second operational year, yielding an estimated €71,387 in profit. By year five, this figure is expected to increase to €82,641, showcasing consistent growth over the five-year horizon. Cumulative returns on investment are projected at a substantial €287,690 affirming the venture's long-term viability. **DISCUSSION:** While these financial projections are promising, it is essential to acknowledge that the real-world outcomes are subject to fluctuations due to changing market conditions, as well as operational efficiency. Therefore, prudent management and adaptability to evolving circumstances are imperative (Škorić, 2018). **CONCLUSIONS:** The significance of nautical tourism to Croatia's economy cannot be overstated. By extending the traditional tourist season and showcasing the nation's picturesque coastline, this entrepreneurial project seamlessly aligns with the growing nautical tourism sector. Its implementation promises to contribute significantly to sustainable growth within this industry and drive economic prosperity.

Keywords: Nautical Tourism, Entrepreneurship, Sailing, Financial Analysis, Organization

Trend Analysis of The Development of Male Swimmers in Front Crawl Disciplines at The National Championships

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ABSTRACT

INTRODUCTION: Swimming has a progressive trend in growing results. Freestyle has undergone many changes in swimming strokes and rules. Today we are witnessing different styles of freestyle techniques. The aim of the research is the analysis of the trend of the results development in the 50-meter and 100-meter disciplines of freestyle technique among Croatian swimmers at the Croatian Championship in the 50-meter pool from 2006 to 2019 **METHODS:** The sample of respondents in this survey includes swimmers from the PH Finals. The sample of respondents for each state championship that took place is defined by a set. The variables used in the study were: 50m and 100m freestyle. The collected data were processed by a method, algorithm, and trend analysis program with the Statistica 13 software package. Multiple regression analysis deals with the average final results and 1st places development trend. **RESULTS:** The analysis of the results of the first eight finalists in the 50-meter freestyle, as well as the analysis of the first places in the 50-meter and 100-meter freestyle at the PH, did not establish a linear growth of the results. Only in the discipline of 100 meters free, where all the finalists were observed, linear growth of the results was determined. The results are varied, the connection between the results is small, and statistical significance is present only in the 100m discipline, where the average results were analyzed. **DISCUSSION:** Polyurethane costumes, did not have a big impact on the results at the PH, except in 2009, when the fastest 100m was swum both individually and on average. All finalists were members of the Croatian national team. The development of results in 2016 is attributed to Sever. At the next PH in 2017, younger swimmers performed, and one still represents the backbone of Croatian swimming (Miljenić), which resulted in a drop-in result. The fight for first place in 2017 and 2018 indicates a possible development of swimming and a return to the top. The medal winners in 2019 at PH were juniors. This possibly indicates a change of generations, that is, the long-standing practice of Croatian swimmers going to study in America. **CONCLUSIONS:** We are witnessing negative development in the results of Croatian swimmers. It calls for urgent reflection and analysis by the leaders of the Croatian Swimming Association and defining the strategy for the development of Croatian swimming.

Keywords: swimming, freestyle, Croatian Swimming Federation, development

Analysis of Trend Development of Results in Dolphin Technique Disciplines for Female Swimmers at The World and National Championships in The Period From 2006 To 2022

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ABSTRACT

INTRODUCTION: Swimming results are constantly improving. The aim of the research is to analyze development trends and the determination of the development curve of the results in the 50m, 100m and 200m butterfly of female swimmers in the finals of the world (WC) and national championships (PH) in the 50-meter pool in the period from 2006 to 2022, as well as differences in results of the mentioned disciplines between Croatia and the world. **METHODS:** The sample of participants consists of female swimmers who competed in the finals of WC and PH. The data were taken from the official websites of the World Aquatic and the Croatian Swimming Federation. The data were processed with the Statistica 14 for trend analysis. The development trend of the average and the best results from the final races was processed using multiple regression analysis. ANOVA was used to compare the differences between the average and best results of the WC and PH. **RESULTS:** The results showed a linear increase in results in almost all disciplines. The only exception is found in the discipline of 200m butterfly at WC where is a negative trend in the development of results. A comparison of the results of the WC and PH indicated a statistically significant difference in all disciplines. **DISCUSSION:** Linear trend in the development of results (50m and 100m) and the percentage of progress vary from year to year. The variation can be attributed to the large range of years analyzed, fast swimming suits, and changes in the training process. The negative trend on 200m is because of the absence of swimming costumes. The biggest drop in results 200m was in 2019 at the WC, probably due to a generational change. Six swimmers who had not performed never before in the finals appeared in the finals. At WC 2017, the best result and the best average of 100m was achieved. The best result is a record owned by the excellent Sjoestroem. The best result and the best average at PH were achieved in 2022. It gives hope that the Croatian swimming is improving. Croatian swimmers are significantly behind the world results. There are many factors that influence success. One of them is certainly the improvement of the entire system. **CONCLUSIONS:** Based on the obtained results, it is possible to forecast the results, which represent an important tool in the development of results.

Keywords: swimming, butterfly, progress, comparison

Trend Analysis of The Development of Male Para Swimmers Sport Classes 'S9' In Front Crawl Stroke Disciplines in The World From 2010 To 2019

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ABSTRACT

INTRODUCTION: S9 is a sports class of para swimmers within the para swimming system, at competitions recognized by the IPC (International Paralympic Committee) and WPS (World Para Swimming), which in most cases is combined with the SB8 and SM9 classes where the competitors mostly have one amputated limb. The letter "S" in the class name stands for freestyle, backstroke and butterfly; the letters "SB" stand for breaststroke, while "SM" stand for individual medley. Generally speaking, this class includes swimmers who mostly have a disability in one limb, but also includes people with cerebral palsy. Para swimmers with amputations are divided into para swimmers with upper limb amputation and lower limb amputation (Vanlandewijck, Thompson, 2011). The aim of the research is to analyze the trend and determine the development curve of the eight best results in the world among S9 class para swimmers from 2010 to 2019 in the disciplines of 50, 100 and 400 meters crawl technique. **METHODS:** The sample of respondents consists of the eight best world results from 2010 to 2019 in paraswimming for the S9 class. The variables used in the research are 50 m, 100 m and 400 m crawl technique for para swimmers of class S9. The data was collected on the official website of the World Para Swimming Organization (World Para Swimming Rankings). Polynomial regression analysis was used to determine the development trend of the best results in a given year for each discipline. **RESULTS:** Polynomial regression analysis was used to analyze the development trend of the average of the final results, and a simple linear relationship was found. In the 50 m crawl, the best results were achieved in 2019, where the coefficient of determination shows a medium correlation of results (R^2 0.32, p, 0.000000). In the 100 m crawl, the best results were achieved in 2019, where the coefficient of determination u shows medium correlation of the results (R^2 0.20; p, 0.000000). In the 400 m crawl, the stagnation of results over the years is visible. **DISCUSSION:** According to several years of research, analyzing Paralympic competitions compared to swimming competitions, it has been shown that: a) the start time (first 15 meters) is best correlated with the total race time, showing almost perfect correlations for the S7 classes (r = 0.90), S8 (r = 0.97) and S10 (r = 0.90); b) lap time showed a high correlation for all classes (r = 0.78 to 0.89) and c) race finish at least of three race times for all classes, showing moderate to high correlations (r = 0.30 for class S8 to r = 0.67 for class S10) (Riewald, Rodeo. 2015, p. 539). Since the IPC swimming classification system was first introduced in 1985, there are few peer-reviewed scientific papers in the field of bio-mechanics, physiology or psychology examining the performance of swimmers with disabilities, especially para swimmers until 2016. In contrast, the number of scientific papers in swimming for non-disabled swimmers in the same period grew exponentially. Based on this, it is clear that more research is needed to identify the factors that influence the performance of para swimmers (Tweedy, Vanladewijck, 2011). With the introduction of the new classification system, it can be noted that there is a significant improvement in the trend of results in the 50-meter and 100-meter

crawl technique at the world level. **CONCLUSIONS** Based on this, it can be concluded that over time the evolution and progression of swimmers with disabilities is much better and faster compared to previous periods, and that the difference between swimmers and para swimmers is getting smaller. The revision of the classification of para swimmers had a great influence on the development of results in paraswimming.

Keywords: para swimming, World Para Swimming Rankings, classifications, results

Health Issues and Prevention in Channel Swimming: Qualitative Study

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ABSTRACT

INTRODUCTION: Even though channel swimmers are typically well prepared, they can still encounter serious health risks such as hypothermia (Brannigan et al., 2009; Gajda et al., 2019; Gerrard, 1999; Judelson et al., 2015), afterdrop (Nuckton et al., 2014), swimming-induced pulmonary edema (Alonso et al., 2017; Gajda et al., 2019; Gerrard, 1999; Hull & Wilson, 2018; Melau et al., 2019; Rogers et al., 2015; Smith et al., 2017), exercise-associated hyponatremia (EAH) (Rogers et al., 2015), exercise-associated hyponatremic encephalopathy (EAHE) (Rogers et al., 2015), cardiac arrest (Gajda et al., 2019), shoulder pain as result of microtrauma (Gerrard, 1999), or injuries caused by marine life (Gajda et al., 2019). There is a lack of systematic evidence about health issues and prevention in channel swimming. **METHODS:** Semi-structured interviews were conducted using the Zoom platform. All interviews were transcribed. Qualitative data was analyzed using a thematic analysis approach. **RESULTS:** Out of 30 interviews that were conducted, 20 were male swimmers, and 10 were female from 14 different countries. Different health issues occur before (shoulder problems, back problems, chronic health issues, etc.), during (hypothermia, jellyfish stings, seasickness, shoulder problems, etc.), and after a swim (shoulder pain, not sleeping, jellyfish stings, sunburn, afterdrop, SIPE, etc.). Different prevention methods are used before (good diet, physical therapy, adequate rest, dryland training, etc.), during (good feeds, medication, sunscreen, etc.), and after a swim (good nutrition, light training, good rest, etc.). There is a correlation between health problems and prevention measures, where prevention before affects health issues in all phases, prevention during affects health issues during and after a swim, and prevention after affects health issues after a swim. **DISCUSSION:** Our research confirms results from previous research highlighting some health issues such as hypothermia that are mentioned in numerous research (Brannigan et al., 2009; Gajda et al., 2019; Gerrard, 1999), SIPE as one of the most dangerous health issues (Alonso et al., 2017; Gajda et al., 2019; Gerrard, 1999), shoulder pain as one of the most occurring health problem and one that occur in all the phases of the swim (Gerrard, 1999). Prevention measures play a key role in all the phases of the swim, especially prevention before the swim as it affects all phases. **CONCLUSIONS:** Channel swimmers can be affected by numerous health problems. Health issues and prevention measures are closely linked in channel swimming and affect each other in all phases.

Keywords: hypothermia, SIPE, afterdrop, jellyfish stings, shoulder pain

Awareness of The Importance of The Competence of Movement in The Water of Respondents of Different Professions

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ABSTRACT

INTRODUCTION: For the concept of competence, there are various definitions and many scientific and professional works dealing with this issue. In this research, we used the definition of competence from the Oxford dictionary in 2003. "Competence is explained as: having the necessary knowledge and ability to do something successfully and as a set of related knowledge, attitudes, skills and other personal characteristics that affect the main part of one's job". Also, in this paper, we will base ourselves on the concept of awareness, which represents a psychological function. Due to the insufficient competences of movement in water, many people drown, and the goal was to see how many people of different professions are aware of this problem. Competences for movement in water include: jumping into water, immersing the head in water, breathing and breathing control below and above the surface of the water, rotation of the body around the longitudinal, transverse and sagittal axes in the horizontal and vertical position of the body on the water. The aim of this research is to gain an insight into the level of awareness of the importance of the competences of movement in water between different populations. **METHODS:** The subjects of this research were first- and second-year students of the University of Zagreb's Faculty of Kinesiology (127 respondents), second-year students of the University of Zagreb's Faculty of Economics (188 respondents), and teachers of classroom and subject classes in elementary schools in Zagreb and Rijeka (76 respondents). The research was conducted through a questionnaire using a Likert scale of agreement or disagreement through 22 statements. The collected data were processed in the statistical data processing program Statistica. The basic statistical indicators obtained on the frequency of responses for collective and separate variables were calculated with analysis of variance (ANOVA) and Student t- test for indenpendent variable. **RESULTS and DISCUSSION:** The results of descriptive statistics show that the highest results were recorded in claim number 12 (mean=4.51), and the lowest in claim number 18 (mean=2.34). According to the results of the Student's t-test, the subjects of the Faculty of Kinesiology in Zagreb showed the greatest statistically significant difference compared to the subjects of the Faculty of Economics in Zagreb and Professors in statement number 2. Given that the competencies of movement in water are very important in the prevention of drowning, it is extremely important to arouse awareness of the general population about this problem and find ways to educate parents, adolescents, children and adults. This research also mentions professors who have an exceptional role in raising and educating children, and their attitude about the importance of knowledge of movement in water is important. **CONCLUSIONS:** The recommendation of this research is to raise the awareness of the respondents, as well as the wider population, about the importance of swimming competences for safe movement in water and about the importance of education from an early age in order to prevent negative outcomes in the form of drowning in water.

Keywords: swimming, drowning, students, professors

FULL TEXTS

Epidemiology of Injuries in 49er Sailing Class

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ABSTRACT

Olympic sailing is a globally popular sport performed on the sea with multiple sailing classes and the two-person skiff or 49er, is one of the newer classes and has two different positions on the boat. The load on sailors during training and competition, along with unstable conditions on the sea and the need to manipulate the boat, represents significant injury risk factors. Therefore, this study aimed to identify types, mechanisms, distribution and characteristics of injuries in the 49er class. Participants in this study were 42 sailors (23 male, 19 female, average age 25.6 years) in the 49er class. All data was collected during the 2023 Sailing World Championship in Hague, Netherlands with an online questionnaire consisting of general personal information, sports factors, and injury information. Women had more proportion of injuries but not significantly ($\chi2=0.47$, $p=0.49$) and there was no difference between boat positions ($\chi2=0.27$, $p=0.6$). Almost two-thirds of reported injuries were caused by trauma, while 62% were noncontact. Additionally, 69% of injuries were sustained during the training. Ankle and foot were the most frequently injured body parts, while fractures and ligament sprains most common injury types. Considering the elite sample, authors believe that this information can help to create preventive strategies in order to reduce the frequency of injuries in 49er sailing**.**

Keywords: Olympic sailing, injuries, lower body, fracture, sprain

INTRODUCTION

Olympic sailing is a globally popular sport sport performed on the sea with multiple sailing classes. In particular, the International Sailing Federation (ISAF) recognizes 10 Olympic classes: Laser Standard (Male One-Person Dinghy), Laser Radial (Female One-Person Dinghy), 470 Men and Women (Two-Person Dinghy), Finn (Male One-Person Heavy Dinghy), 49er (Male Two-Person Skiff), 49erFX (Female Two-Person Skiff), Nacra 17 (Mixed Two-Person Multihull), and RS:X Men and Women (One-Person Sailboard) (Tan, Leong, Pardal, Lin, & Kam, 2016). Although demands differ between classes, Olympic sailing is in general physiologically demanding sport with the crucial importance of aerobic metabolism and strength components (Bojsen-Møller, Larsson, Magnusson, & Aagaard, 2007). In the team classes, sailors are categorized by their position and have different tasks during the race. Two-person skiff or 49er,

is one of the newer classes and has two different positions on the boat. The crew is responsible for the sail control while the helmsmen's major task is making tactical decisions (Feletti & Madaffari, 2022). Boats in this class are fast and unstable and considering wind and wave conditions and the long duration of the training or competition, the load imposed on the sailor's bodies is significant.

This load puts sailors at a certain risk of injuries. Although the rate of injuries is lower than in some other team sports (0.59 injuries per 1000 h of sailing, as reported in some studies), studies have recorded the occurrence of acute and chronic injuries caused by the specifics of sports (Tan et al., 2016). In general, due to direct contact with different boat parts, contusions, lacerations and fractures are possible. Also, repetitive actions like hiking, grinding winches and steering can result in overuse, and chronic problems (Nathanson, Baird, & Mello, 2010). During sailing, sailors often stand in uncomfortable, awkward positions caused by unpredictable movements of the vessel, and a lot of sudden movements occur at irregular time intervals which all represent a risk of getting injured (Allen & De Jong, 2006). Besides these sailing specifics, among the most significant risk factors for sailing injuries, studies highlight poor conditioning, overuse and overtraining (Joanne, 1999). In general, the majority of injuries are chronic (58%), and the most frequently injured body parts are the lower back, knee, shoulder and ankle (Tan et al., 2016). Regarding injury types, contusions, lacerations and sprains are most common (Tan et al., 2016).

Although there are epidemiological studies of injuries in sailing, they were mainly focused on individual classes (Nathanson et al., 2010). Also, there is still no clear consensus about the way of recording and collecting injuries, as is present in some other sports, which would unify their identification. Therefore, this study aimed to investigate sailing-related injuries among the 49er class, using the adopted injury report form, and to provide details regarding injury incidence, severity, type of injuries and injured body parts.

METHODS

Participants in this study were 42 sailors (23 male, 19 female, average age 25.6 years) in the 49er class. There were 22 sailors in crew position and 20 helmsmen. All participants are experienced sailors with an average of 8.04 years experience in this Olympic class and participation on the highest competitive stage (Olympic games, World Cup, European Championship).

All data was collected during the 2023 Sailing World Championship in Hague, Netherlands. Data was compiled through an online questionnaire consisting of (i) general personal information (age, body height, body mass), (ii) sports questions (sailing experience, status, boat position), and (iii) an injury report that was based on already existing validated questionnaires used in football and rugby (Fuller et al., 2006; Fuller et al., 2007). All injuries were self-reported and the participants had to recall all sustained ones in their 49er competitive period. Injuries were classified based on: days out from training, injured body part, injured side of the body, type of injury, existence of a previous injury of the same type at the same site, injury character (trauma or overuse), occurrence of the injury (training or competition) and contact nature of the injury.

All data were descriptively analyzed with means, standard deviation and frequencies and percentages calculated for the observed variables. The chi-square test was used to determine differences in injury occurrence between genders and boat positions. Statistica ver. 13.5 (Tibco Inc., Palo Alto, CA, USA) and Microsoft Excel 2019 (Microsoft, USA) were used for all calculations, with a significance level of $p < 0.05$.

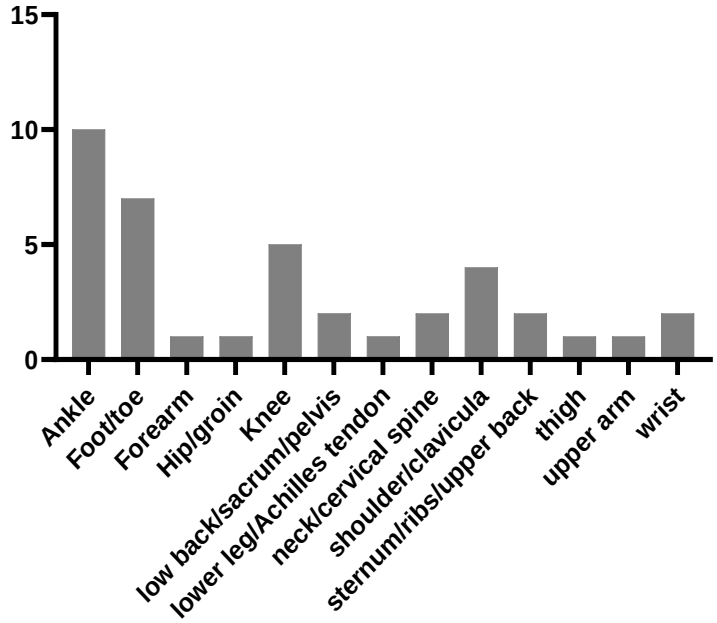
RESULTS and DISCUSSION

Out of 42 tested sailors, 31 of them experienced at least one injury while sailing in the 49er class, while 11 of them did not miss any training due to injury. Women had more proportion of injuries but not significantly ($\chi2=0.47$, $p=0.49$) Regarding injury relation with boat position, more percentage of helmsmen were injured compared to the crew (80% and 68% respectively) but also with no statistically significant difference ($\chi2=0.27$, $p=0.6$). The average days of missed training and/or sailing competition was 53.32, while eight of the total 39 injuries reported were reinjuries. Almost two-thirds of reported injuries were caused by trauma, while 62% were noncontact. Additionally, 69% of injuries were sustained during the training.

Table 1. Injury classification

	AVE	*SD*
DAYS OUT	*53,52*	*98,79*
	NO	*YES*
REINJURY	*31*	*8*
	OVERUSE	*TRAUMA*
TYPE	*14 (36%)*	*25 (64%)*
	TRAINING	*COMPETITION*
OCCURRENCE	*27 (69%)*	*12 (31%)*
	YES	*NO*
CONTACT	*15 (38%)*	*24 (62%)*

Figure 1. Injured body parts



Injury distribution by body parts is graphicly presented in Figure 1. with the ankle (20 injuries) and foot (7 injuries) as the most frequently injured body parts.

Figure 2. Types of Injuries

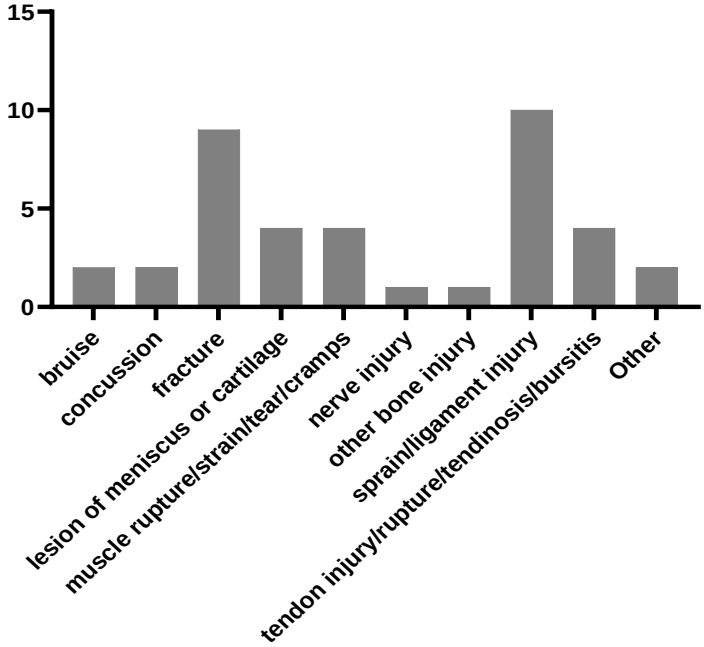


Figure 2. shows the distribution of injuries by type, where sprains of the ligament (10) and fractures (9) are the most common.

One of the most important findings of this research is the higher incidence of traumatic injuries compared to chronic ones. This result may seem surprising at first, given that previous studies have usually reported a higher number of overuse injuries in sailors (Leong, Pardal, Tan, & Lin, 2014; Tan, Leong, & Ong, 2011). However, it is important to emphasize that these studies were mostly done in a large number of classes. One of the more recent studies that analyzed injuries specifically within sailing classes, determined that the 49er and 49erFX classes are the only ones with a higher incidence of traumatic injuries (Tan et al., 2016). Participants in that study pointed out the foot strap as the part of the boat most often associated with injuries because the foot would usually remain stuck in the strap during sudden decelerations and fast turns. There is still a need to create a new type of foot strap that will release in case of an excessive amount of force is applied. Considering these 49er specificities, it is not unexpected that most injuries occurred on the lower leg and that fractures and ligament sprains were most frequent. Studies reported that most of the fractures among sailors happen in the 49er class (Tan et al., 2016). One of the most dangerous and fatal injuries in sailing are concussions and head injuries. Previous studies found similar rates of these injuries as here (5%), and for the safety of sailors, the introduction of protective helmets is suggested (Nathanson et al., 2010).

In terms of injured sites of the body, the lower extremities are most frequent, followed by the shoulders and the lumbar part of the back. Although in general, in sailing, injuries to the upper extremities are even more common, the aforementioned specifics of the 49er class explain the high rate of injuries to the lower extremities, specifically ankles and feet (Andrew Nathanson, 2019). As a rule, lower back injuries are chronic injuries caused as a result of the specific position of the sailor, in which this part of the spine is under high load and the musculature is in strong isometric and dynamic contraction. These and previous results indicate the need for additional preventive work for lower back injuries.

Another important finding of this research is the absence of a significant difference in the injury rate between men and women. This result is contrary to previous findings, where women regularly had a higher number of injuries in all classes. Another important finding of this research is the absence of a significant difference in the injury rate between men and women (Tan et al., 2016). This result is contrary to previous findings, where women regularly had a higher number of injuries in all classes. Given that there have been no studies that have studied this in recent years, we can assume that women have to some extent eliminated certain risk factors for injury, primarily sailing experience and the level of psychomotor capacities.

CONCLUSION

This study aimed to identify injury occurrence among elite 49er sailors. Results showed that most injuries occur during the training as a consequence of trauma. Lower body (ankle and foot) were the most frequently injured body sites and sprains and fractures were the most common types of injuries.

There are several limitations of this study. First of all, injuries were not classified by official medical staff, since they were retroactively self-reported by the sailors themselves which leaves the possibility that not all injuries were noted. Information on training and competition exposure is one of the most important ones to establish the real risk of injury in a particular sport, so this information should be collected in future studies. However, considering the elite sample, authors believe that this result can help identify the character, type and frequency of injuries among sailors in the 49er class. In this way, it is possible to create preventive strategies in order to reduce the frequency of injuries in sailing**.**

REFERENCES

1. Allen, J. B., & De Jong, M. R. (2006). Sailing and sports medicine: a literature review. *British journal of sports medicine, 40*(7), 587-593.
2. Andrew Nathanson, M. (2019). Sailing injuries: a review of the literature. *Rhode Island Medical Journal, 102*(1), 23-27.
3. Bojsen-Møller, J., Larsson, B., Magnusson, S. P., & Aagaard, P. (2007). Yacht type and crew-specific differences in anthropometric, aerobic capacity, and muscle strength parameters among international Olympic class sailors. *Journal of sports sciences, 25*(10), 1117-1128.
4. Feletti, F., & Madaffari, A. (2022). Running in Sailing. In *The Running Athlete: A Comprehensive Overview of Running in Different Sports* (pp. 255-264): Springer.
5. Fuller, C. W., Ekstrand, J., Junge, A., Andersen, T. E., Bahr, R., Dvorak, J., . . . Meeuwisse, W. H. (2006). Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries. *Scandinavian journal of medicine & science in sports, 16*(2), 83-92.
6. Fuller, C. W., Molloy, M. G., Bagate, C., Bahr, R., Brooks, J. H., Donson, H., . . . Meeuwisse, W. H. (2007). Consensus statement on injury definitions and data collection procedures for studies of injuries in rugby union. *British journal of sports medicine, 41*(5), 328-331.
7. Joanne, B. (1999). Sports medicine and sailing. *Physical medicine and rehabilitation clinics of North America, 10*(1), 49-65.
8. Leong, D., Pardal, C. V., Tan, B., & Lin, C. (2014). INJURY AND ILLNESS PATTERNS IN COMPETITIVE SAILORS OF THE 43RD ISAF YOUTH SAILING WORLD CHAMPIONSHIP–A 12-MONTH RETROSPECTIVE STUDY. *British journal of sports medicine, 48*(7), 625-625.
9. Nathanson, A. T., Baird, J., & Mello, M. (2010). Sailing injury and illness: results of an online survey. *Wilderness & environmental medicine, 21*(4), 291-297.
10. Tan, B., Leong, D., & Ong, A. (2011). Injury Patterns of Competitive Sailors in Olympic Classes: 1576: Board# 109 June 1 2: 00 PM-3: 30 PM. *Medicine & Science in Sports & Exercise, 43*(5), 355.

11. Tan, B., Leong, D., Pardal, C. V., Lin, C. Y., & Kam, J. W. (2016). Injury and illness surveillance at the international sailing federation sailing world championships 2014. *British journal of sports medicine, 50*(11), 673-681.

Femoroacetabular Impingement Syndrome Therapy and Rehabilitation

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ABSTRACT

Femoroacetabular impingement (FAI) is a chronic condition that characteristically presents with hip pain due to mechanical impingement from abnormal hip morphology involving the femoral head and/or acetabulum. FAI has been identified as a primary source of hip pain as well as responsible for up to half of all hip osteoarthritis. The symptoms include hip/groin pain aggravated by activity or sitting, commonly with referral to the buttocks, thighs, or knees. Patients also frequently report "clicking, catching, locking, stiffness ". They often present with decreased range of motion (ROM). The most common movements of the hip that are restricted by cam lesions include flexion, internal rotation, and adduction. On physical examination, patients with FAI will typically have a positive FADIR test (Flexion, Adduction, Internal Rotation Test), also known as a positive impingement sign. Questionnaires, such as the modified Harris Hip Score (mHHS) and various International Hip Outcome Tools (iHOT-33, iHOT-12). Anterior-posterior (AP) radiographs are used to identify the specific osseous changes and rule out other origins of hip pain. Both cam and pincer lesions are visible on plain radiographs (X-ray). It is possible to conclude that supervised physiotherapy programs focusing on active strengthening and core strengthening are more effective than unsupervised, passive, and non–core focused programs. Such protocols should be supervised by a team consisting of a surgeon, physical medicine and rehabilitation specialist and physiotherapist.

Keywords: hip, physiotherapy, FADIR

INTRODUCTION

Femoroacetabular impingement (FAI) is a chronic condition that characteristically presents with hip pain due to mechanical impingement from abnormal hip morphology involving the femoral head and/or acetabulum. Such malformations result in irregular forces and contact across the joint and bone which often lead to labral, cartilaginous and tissue damage after repetitive abutment of the hip structures. FAI has been identified as a primary source of hip pain as well as responsible for up to half of all hip osteoarthritis.

Morphologic variations of FAI present as either aspherical femoral deformity (cam deformity) or overcoverage (pincer deformity) or both (mixed). Cam deformity is an abnormal bony

prominence or "bump" at the junction of the femoral head and neck resulting in an aspherical-shaped head, occurring most commonly along the anterosuperior femoral head-neck area. It is thought to be more common in adolescents engaged in high-intensity sports. They were found to be ten times more likely to have a cam deformity and impingement than age-matched adolescents not participating in high-intensity sports. There is a theory that increased stress along the growth plate of the hip leads to increased stress reaction bone formation resulting in cam deformity and subsequent impingement (2). A pincer lesion is an abnormal bony overhang of the anterolateral acetabular rim resulting in over coverage of the femoral head. The source of pincer development remains elusive. A combination or mix of both cam and pincer lesions is the final classification of FAI. Mixed morphology is the most common in symptomatic patients. Excess bone formation on the acetabular rim and the proximal femur frequently damage both the acetabular rim cartilage and the labrum to varying degrees. Patients with mixed FAI morphology will often have a worse clinical prognosis as compared to cam or pincer lesions alone. Severity is measured with two calculated angles: the alpha (α) and lateral central-edge angles (LCEA) for cam and pincer lesions, respectively (4).

The acetabular labrum is a fibrocartilaginous ring which surrounds the circumference of the acetabulum of the hip. It is triangular in cross-section. It embraces the femoral head and cushions the joint, preventing the bones from directly rubbing against each other. It's innervation primarily comes from a branch of the nerve to the quadratus femoris as well as the obturator nerve. In FAI, the labrum gets crushed between the acetabular rim and femoral neck. On examination, the impingement test (flexion, internal rotation and adduction) primarily stresses the antero-superior aspect of the labrum, and pain with this maneuver may well be originating from abundant nerve endings in this zone. Labral tears are also more common in the antero-superior zones of the labrum in FAI. The presence of abundant free nerve endings in these zones transmitting nociception clearly explains the symptoms of acute pain with labral tears (7). The prevalence of FAI in the general adult population is between 10 to 15%. Cam deformity is more prevalent in men than women, with a reported prevalence of 9 to 25% men versus 3 to 10% in women. Pincer lesions are more common in women than men, with reports of 19.6% versus 15.2%. The prevalence of anatomic morphology consistent with this condition has also been shown in asymptomatic individuals. A meta-analysis by Frank et al. reports a prevalence of 37% for cam deformity and 67% for pincer deformity in asymptomatic volunteers. When accounting for the athletic population, cam deformity prevalence was 54.8% for athletes and 23.1% for non-athletes. The pincer lesion was present in 49.5% of the athletic population (20).

Symptoms, clinical signs and imaging: The symptoms include hip/groin pain aggravated by activity or sitting, commonly with referral to the buttocks, thighs, or knees. Patients also frequently report “clicking, catching, locking, stiffness “. They often present with decreased range of motion (ROM). The most common movements of the hip that are restricted by cam lesions include flexion, internal rotation, and adduction.

On physical examination, patients with FAI will typically have a positive FADIR test (Flexion, Adduction, Internal Rotation Test), also known as a positive impingement sign. This exam is performed with the patient lying supine as the clinician flexes the leg 90 degrees, adducts the entire leg across the patient's midline, and abducts the calf and foot while maintaining the knee in position. A positive test is elicited if the patient endorses hip pain during the final step. Patients with FAI will often exhibit a positive FABER test as well. In this maneuver, the patient lies supine while the affected leg is flexed, abducted, and externally rotated. While the examiner stabilizes the contralateral pelvis, downward force is exerted on the affected leg. The test is positive if the knee of the affected leg is raised as a result of the downward force.

Questionnaires, such as the modified Harris Hip Score (mHHS) and various International Hip Outcome Tools (iHOT-33, iHOT-12), are available to quantify a patient's history, but no assessment tool has been cited as the criterion standard in the literature (1).

Modified Harris Hip Score: This questionnaire was modified from the original Harris Hip Score. The questionnaire assesses the following functional areas: gait (limp, assistive devices, distance); stair climbing, squatting, and sitting with lower extremities crossed; ability to use public transportation; hip range of motion; and overall pain. Total score ranges from 0 to 100, with <70 indicating a poor result and >90 indicating an excellent result.

International Hip Outcome Tool-33 – This 33-item questionnaire is used to assess health-related quality of life and was developed predominantly for research purposes. Questions relate to symptoms, functional limitations, sport and recreational activities, job-related concerns, and lifestyle concerns. Visual analog scale scores are summed, and the total score ranges from 0 to 100, with 100 representing the best score (1).

Anterior-posterior (AP) radiographs are used to identify the specific osseous changes and rule out other origins of hip pain. Both cam and pincer lesions are visible on plain radiographs (X-ray). Chondrolabral lesions should be evaluated with unenhanced MRI or MR arthrography. The protocol should include a large-FOV fluid-sensitive sequence to exclude conditions that can mimic or coexist with FAI, radial imaging to accurately determine the presence of a cam deformity, and imaging of the distal femoral condyles for measurement of femoral torsion. CT remains a valuable tool for planning of complex surgical corrections. Ultrasound can mostly be useful in determining the cam deformity (10).

Treatment of FAI consists of conservative therapy (activity modification, oral medications, physical therapy) or surgical options, with the latter reserved for patients that fail conservative treatment or present initially with severe symptoms.

Formal nonoperative protocols to manage FAI syndrome using high-evidence study designs are scarce. However, all patients should undergo a trial of non-operative management prior to surgery, which has been shown to be successful in approximately 39–82% of FAI syndrome cases (13). Conservative treatment is typically considered first-line treatment for mild to moderate FAI syndrome as it can provide marked symptomatic relief. Conservative therapy consists of an

intensive, long term physical therapy program specified toward the individual's symptoms. In the acute phase, reducing painful activity is warranted. Patients should increase rest and use nonsteroidal anti-inflammatory medications or analgesics as needed for pain management. Patient education should encourage improved postural awareness as well as avoiding sitting cross-legged, positions of deep hip flexion, adduction and internal rotation and movements such as full squat. Sports such as cycling, running on a treadmill, or running narrow straight trails should be avoided during initial treatment since they involve simultaneous hip flexion and internal rotation. Walking and swimming can benefit patients with FAI syndrome as a viable exercise alternative (8,9). Patients who received 12 weeks of physical therapy that included hip and core strengthening, manual therapy, and lifestyle education reported improved outcomes (iHOT-33). An 8-week core strengthening program of pelvic-tilt, bird-dog, hip-extension and isometric core-strength exercises and lifestyle management improved hip flexion and hip-adduction strength (1). Pennock et al explored the use of a nonoperative exercise protocol to manage FAIS in 76 adolescent and young adult athletes. Seventy percent were successfully treated using structured therapy, activity and sport-skill modification, and rest (11). In a recent meta-analysis of 5 randomized controlled trials, it was observed that nonoperative treatment was an effective initial option for managing patients with FAIS. Collectively, the nonoperative programs that were focused on hip and core strengthening in a supervised environment resulted in better patient-reported outcomes (12). However, conservative therapy should not be the first treatment option for all patients. Instead, the type of morphology may help guide the decision-making process. For instance, evidence has demonstrated that patients with a cam deformity have worse outcomes from conservative treatment as compared to other types of FAI syndrome. While conservative therapy can relieve symptoms in carefully selected patients, it is not significantly helpful in most patients with FAI syndrome. Even with long-term physical therapy regimens, the outcomes following postoperative intervention remain significantly better than physical therapy alone (3). A study has observed that surgical intervention early after the onset of symptoms (3-6 months) was associated with superior postoperative outcomes when compared with patients who underwent surgical intervention beyond this time frame, suggesting that surgical intervention may be needed if symptoms have not resolved with nonoperative treatment within 3 to 6 months (19).

Surgical Treatment - The goal of FAI surgery is to re-establish the normal relationships between the components of the hip joint to restore normal function. Diagnostic imaging is the most useful criterion to determine if surgery is indicated. Additional criteria include subjective symptoms, clinical signs, and the failure of conservative therapy. The most common surgical treatment option for FAI is addressed arthroscopically. An increased understanding of the importance of chondrolabral preservation and associated labral repair has since increased the effectiveness of arthroscopic surgical repair of FAI syndrome. Additionally, recent literature regarding capsular closure after hip arthroscopy has shown to improve

postoperative outcomes. The most important ligament to repair in a capsular closure is the iliofemoral ligament as it is necessary for the long-term stability of the hip while also ensuring an appropriate range of motion. The iliofemoral ligament is difficult to avoid disrupting during surgery because both the interportal and T-capsulotomy techniques result in direct injury to the ligament. These approaches are particularly favorable for athletes as it results in a higher likelihood of returning to sport with a low risk for complications as compared to other capsulotomy techniques. On the contrary, while the arthroscopic repair of FAI and labral associated injuries have been proven successful in young adults, the outcomes are inconsistent in older populations. However, in general, arthroscopic surgical approach has been proven to be a superior treatment option over conservative treatment in those who can undergo a surgery (3).

Aside from hip arthroscopy, there are other less common surgical treatment options. Historically, open surgical treatment of FAI was common as it allowed the greatest visualization and ability to easily reach the femoral head, the labrum, and the acetabulum. An open surgical approach remains helpful for particularly difficult cases of FAI syndrome that require more access to the joint than arthroscopy alone can provide. This is commonly seen in patients presenting large and/or complex cam or pincer deformities. It is also commonly used for revision surgeries initially performed with arthroscopy due to inadequacy of arthroscopy to access the deformity.

Another less commonly used technique is an anterolateral approach, also known as the Watson-Jones technique, which is used primarily for anterolateral deformities. The benefit of this technique is that it provides direct access to anterior lesions while preserving the blood supply to the femoral head. In addition, another less common surgical approach is the combined mini-open with arthroscopy. This technique avoids dislocating the hip while still addressing FAI malformation. However, although it is less invasive than an open approach, this combined technique can only treat cam-type lesions because the acetabulum cannot be accessed accurately without dislocation (4).

Advancements in hip arthroscopy techniques have led to a higher rate of arthroscopic management of this condition over the open surgical dislocation technique. While arthroscopic management has become the most common form of surgical management for FAI, inadequate bony resection has been shown to be a frequent source of revision surgery. Therefore, roles for open surgical dislocation and combined mini-open approaches remain, particularly in cases where concern for the inability to fully access the morphology arthroscopically exists (3).

A meta-analysis of the 3 randomized trials compared the outcomes of patients with FAI syndrome treated with hip arthroscopy versus those treated with physical therapy alone, showing that patients treated with operative management had improved superior hip-related outcomes in the short term compared with those treated with physical therapy alone (6).

Nonetheless, FAI syndrome may not always respond to surgery. Some common causes of failure to respond postoperatively include persisting bony deformities and an inadequate

capsular closure (14). Surgical complications from hip arthroscopy may result in additional surgical intervention and patient costs. The likelihood of successful outcomes after surgery declines as patients age due to more surgical complications, other comorbidities and prolonged rehabilitation.

The average time for return to sport is approximately 7 months (15) with elite-level athletes having displayed a return-to-sport success rate of 84% to 93% after arthroscopic surgery (16,17). Another study has observed that only 57% of athletes who underwent arthroscopy for FAI returned to sport at their preinjury level (18), contending that this contrasting result was due to a stricter definition of return to sport, but such result also shows the importance of extensive communication and collaboration between the surgical and rehabilitation teams as well as their specific approach towards patient's age, sport, goals and expectations. Also, the difficulty of determining timelines for returning to sport is increased even more because of the differences in sports' specifics and requirements. The main conditions before returning to sport should be reestablishing of strength, stamina and body symmetry.

Domb et al. observed 595 patients with labral tears with mechanical symptoms and failure of nonoperative treatment who had surgical intervention. They described an improvement from preoperative to 2-year follow-up of 61.29 to 82.02 for modified Harris Hip Score (mHHS), 62.79 to 83.04 for Hip Outcome Score–Activities of Daily Living (HOS-ADL), 40.96 to 70.07 for Hip Outcome Score–Sport-Specific Subscale (HOS-SSS), and 57.97 to 80.41 for Non-Arthritic Hip Score (NAHS); visual analog scale (VAS) scores decreased from 5.86 preoperatively to 2.94 postoperatively. They suggested a postoperative rehabilitation protocol consisting of four phases;

- phase one lasting for 3 weeks with goals of trying to diminish pain, protect the repaired tissues, and prevent muscle inhibition as well as the development of anterior hip contractures. The postoperative brace and crutches were used for 2 weeks immediately after surgery followed by weightbearing as tolerated after 2 weeks. Isometric exercises are performed in this phase, and passive range of motion (PROM) including circumduction should be performed within restrictions (Flexion 90°, Extension 0°, Abduction 25° to 30°, IR at 90° of hip flexion 0°, IR in prone limited by comfort, ER at 90° of hip flexion 30°, ER in prone position 20°). After 3 weeks, ROM progression is permitted within a pain-free range. Prior to the patients' progression to phase two, full, nonpainful weightbearing must be achieved.
- Phase 2 spans from week 4 through 8, with goals of continued protection of the repaired tissue, restoration of full hip ROM and normal gait patterns, and strengthening of the hip, pelvis, and both lower extremities with emphasis on the gluteus medius. Strengthening activities evolve from partial to full weightbearing positions, including leg press, double- followed by single-leg squats, and step-ups/downs. Double-leg standing with trunk rotation against elastic band resistance and standing shoulder extension against band resistance both help address core strength and stability. Patients progress to triplanar stepping, and balance progression begins with double- followed by single-leg stance activities. Elliptical trainer exercise can be initiated

between 6 and 8 weeks postoperative for up to 10 minutes for cardiovascular endurance. To advance to phase 3 of the postoperative programs, patients must demonstrate full and pain-free hip active range of motion (AROM) in all planes, pain-free normalized gait, hip flexor strength of 4 on manual muscle testing (MMT), hip abduction, adduction, extension, and IR/ER strength of 4 on MMT.

- The goals of phase 3 are the restoration of hip flexor muscle strength to 4 and 4+ for all other hip motions, as well as improving balance, proprioception, and cardiovascular endurance. Precautions include avoidance of contact activities, aggressive hip flexor strengthening, as well as forced or aggressive stretching that elicits pain. Criteria for progression to sport-specific training includes hip flexor muscle strength of 4+ and 5 in all other lower extremity musculature.
- During phase 4, the athlete can begin a jogging progression program along with hopping and agility drills that are customized to the patient's sport and/or work activities. Before return to play (RTP) is considered, full ROM to all planes of the hip and cardiovascular endurance consistent with sport and/or work demands must be demonstrated. Normal strength and flexibility throughout the core and lower extremities are needed to pass RTP testing. RTP testing uses slow-motion video analysis of biomechanical performance and the criteria is sports specific (21).

It is possible to conclude that supervised physiotherapy programs focusing on active strengthening and core strengthening are more effective than unsupervised, passive, and non–core focused programs. Such protocols should be supervised by a team consisting of a surgeon, physical medicine and rehabilitation specialist and physiotherapist. Many different postoperative protocols have been suggested, but there has been limited discussion of outcomes using any of the existing rehabilitation protocols and limited evidence-based research behind treatment principles. Another point of discussion is the pressure in reducing the return to play timeline in professional athletes which often results in surgical intervention as soon as possible.

REFERENCES

1. Terrell SL, Olson GE, Lynch J. Therapeutic Exercise Approaches to Nonoperative and Postoperative Management of Femoroacetabular Impingement Syndrome. *J Athl Train*. 2021;56(1):31-45. doi:10.4085/1062-6050-0488.19.
2. O'Rourke RJ, El Bitar Y. Femoroacetabular Impingement.
1. https://www.ncbi.nlm.nih.gov/books/NBK547699/
2. Maupin JJ, Steinmetz G, Thakral R. Management of femoroacetabular impingement syndrome: current insights. *Orthop Res Rev*. 2019;11:99-108. Published 2019 Aug 27. doi:10.2147/ORR.S138454.
3. Fortier LM, Popovsky D, Durci MM, Norwood H, Sherman WF, Kaye AD. An Updated Review of Femoroacetabular Impingement Syndrome. *Orthop Rev (Pavia)*. 2022;14(3):37513. Published 2022 Aug 25. doi:10.52965/001c.37513.
4. Hoit G, Whelan DB, Dwyer T, Ajrawat P, Chahal J. Physiotherapy as an Initial Treatment Option for Femoroacetabular Impingement: A Systematic Review of the Literature and

Meta-analysis of 5 Randomized Controlled Trials. *Am J Sports Med*. 2020;48(8):2042-2050. doi:10.1177/0363546519882668.

5. Tim Dwyer, Daniel Whelan, Prakesh S. Shah, Prabjit Ajrawat, Graeme Hoit, Jaskarndip Chahal, Operative Versus Nonoperative Treatment of Femoroacetabular Impingement Syndrome: A Meta-analysis of Short-Term Outcomes, Arthroscopy: The Journal of Arthroscopic & Related Surgery, Volume 36, Issue 1, 2020, 263-273.
6. https://www.sciencedirect.com/science/article/abs/pii/S0749806319306681
7. Alzaharani A, Bali K, Gudena R, et al. The innervation of the human acetabular labrum and hip joint: an anatomic study. *BMC Musculoskelet Disord*. 2014;15:41. Published 2014 Feb 14. doi:10.1186/1471-2474-15-41.
8. Pasculli, R.M., Callahan, E.A., Wu, J. *et al.* Non-operative Management and Outcomes of Femoroacetabular Impingement Syndrome. *Curr Rev Musculoskelet Med* (2023). doi: 10.1007/s12178-023-09863-x.
9. Loudon JK, Reiman MP. Conservative management of femoroacetabular impingement (FAI) in the long distance runner. Phys Ther Sport. 2014;15(2):82–90. doi: 10.1016/j.ptsp.2014.02.004.
10. Schmaranzer F, Kheterpal AB, Bredella MA. Best Practices: Hip Femoroacetabular Impingement. *AJR Am J Roentgenol*. 2021;216(3):585-598. doi:10.2214/AJR.20.22783.
11. Pennock A, Bomar J, Johnson K, Randich K, Upasani V. Nonoperative management of femoroacetabular impingement: a prospective study. *Am J Sports Med.* 2018;46(14):3415–3422. doi: 10.1177/0363546518804805.
12. Hoit G, Whelan D, Dwyer T, Ajrawat P, Chahal J. Physiotherapy as an initial treatment option for femoroacetabular impingement: a systematic review of the literature and meta-analysis of 5 randomized controlled trials. *Am J Sports Med*. 2020;48(8):2042–2050. doi: 10.1177/0363546519882668.
13. Schwabe MT, Clohisy JC, Cheng AL, Pascual-Garrido C, Harris-Hayes M, Hunt DM, et al. Short-term clinical outcomes of hip arthroscopy versus physical therapy in patients with femoroacetabular impingement: a systematic review and meta-analysis of randomized controlled trials. Orthop J Sports Med. 2020;8(11). doi: 10.1177/2325967120968490.
14. Mansell NS, Rhon DI, Meyer J, Slevin JM, Marchant BG. Arthroscopic Surgery or Physical Therapy for Patients With Femoroacetabular Impingement Syndrome: A Randomized Controlled Trial With 2-Year Follow-up. *Am J Sports Med*. 2018;46(6):1306-1314. doi:10.1177/0363546517751912.
15. Reiman M, Peters S, Sylvain J, Hagymasi S, Mather R, Goode A. Femoroacetabular impingement surgery allows 74% of athletes to return to the same competitive level of sports participation but their level of performance remains unreported: a systematic review with meta-analysis. *Br J Sports Med*. 2018;52(15):972–981. doi: 10.1136/bjsports-2017-098696.

16. Shibata K, Matsuda S, Safran M. Arthroscopic hip surgery in the elite athlete: comparison of female and male competitive athletes. *Am J Sports Med*. 2017;45(8):1730–1739. doi: 10.1177/0363546517697296.
17. Philippon M, Schenker M, Briggs K, Kuppersmith D. Femoroacetabular impingement in 45 professional athletes: associated pathologies and return to sport following arthroscopic decompression. *Knee Surg Sports Traumatol Arthrosc*. 2007;15(7):908–914. doi: 10.1007/s00167-007-0332-x.
18. Ishøi L, Thorborg K, Kraemer O, Hölmich P. Return to sport and performance after hip arthroscopy for femoroacetabular impingement in 18- to 30-year-old athletes: a cross-sectional cohort study of 189 athletes. *Am J Sports Med*. 2018;46(11):2578–2587. doi: 10.1177/0363546518789070.
19. Kunze K, Beck E, Nwachukwu B, Ahn J, Nho S. Early hip arthroscopy for femoroacetabular impingement syndrome provides superior outcomes when compared with delaying surgical treatment beyond 6 months. *Am J Sports Med*. 2019;47(9):2038–2044. doi: 10.1177/0363546519837192.
20. Frank JM, Harris JD, Erickson BJ, et al. Prevalence of femoroacetabular impingement imaging findings in asymptomatic volunteers: a systematic review. *Arthroscopy* 2015; 31:1199–1204.
21. Domb BG, Sgroi TA, VanDevender JC. Physical Therapy Protocol After Hip Arthroscopy: Clinical Guidelines Supported by 2-Year Outcomes. *Sports Health*. 2016;8(4):347-354. doi:10.1177/1941738116647920.

Differences in Anthropometric Characteristics and Recovery Time in Physically Active and Inactive Students

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ABSTRACT

Physical activity significantly affects the value of anthropometric characteristics which play a major role in the assesment of body composition and enable planning training programs or assesng risk factors for the occurence of some chronic diseases. It is also known that during physical activity heart rate increases, and depending on the degree of exercise, its value differs. This study included 40 male students aged 19 to 23 years (20 physically active and 20 physically inactive) and 20 female students aged 19 to 23 years (10 physically active and 10 physically inactive). Students were measured anthropometric parameters (body height, body weight, BMI, muscle mass and fat percentage), and heart rate and oxygen saturation before and after a given physical exertion. A statistically significant difference ($p< 0.05$) between physically active and inactive male students was found when measuring muscle mass, fat percentage (PBF) and heart rate before and after physical exertion. With regard to female students, a statistically significant difference between the physically active and inactive groups was observed when measuring, muscle mass and heart rate before and after physical exertion. Muscle mass is higher in physically active students of both sexes, while heart rate values are lower. Exercising has the effect of increasing muscle mass and reducing heart rate in students of both sexes, while in male students it also causes a decrease in body fat percentage. Physical activity has a positive effect on certain anthropometric characteristics as well as on the state of the cardiovascular system, which contributes to the improvement of the general condition.

Key words: body composition, heart rate, oxygen saturation, physical activity, general condition

INTRODUCTION

Anthropometric measurements play an important role in the assessment of the body composition of different populations, both in physically active people and athletes, and in people who do not engage in physical activity. Moreover, with this non-invasive and relatively inexpensive method, we can determine a large number of parameters such as body height, body weight, body mass index (BMI), body fat percentage (%BF), muscle mass and many others (1). The representation of different constituent elements in the total body mass of a person is individual and sport greatly affects their values. The body composition of athletes differs from the body characteristics of people who do not play sports and are not physically active. On the other hand, athletes also differ among themselves, which explains the

phenomenon known as "sports morphological optimization", according to which the body composition of athletes depends on the sport they play, as well as the fact that the differences in their anthropometric characteristics are closely related to the demands that athletes have during the selection process (2). On the other hand, physical activity can be effective in all phases of chronic diseases, from primordial prevention, through treatment and rehabilitation (3). Some of the diseases in which physical activity is a form of prevention but also an integral part of therapy are hypertension, coronary disease and diabetes mellitus type 2 (4,5).

Many conditions, including physical activity, require rapid adaptation of the cardiovascular system, and the heart rate is the simplest indicator of the condition of the heart muscle as well as the general state of health (6). The physiological number of heart beats per minute is 60-80 at rest, while in athletes this value drops to 40 beats per minute, while in sedentary people it can reach 100 beats per minute. Heart rate is predominantly influenced by the autonomic nervous system, where the sympathetic nervous system (noradrenaline) as well as the increased demand for oxygen in peripheral tissues (which is the case during physical activity) increase the frequency, while the parasympathetic (vagus nerve) decreases it (7). During exercise, heart rate dynamics is conditioned by parasympathetic inactivation, and later by sympathetic activation, while the opposite happens during recovery. Heart rate recovery in the first minutes after physical activity is a reliable indicator of parasympathetic activity and is a significant prognostic marker and risk factor, both in the healthy population and in the diseased population (8). Better physical condition is closely related to faster heart rate recovery as a result of functional adaptation of the heart due to regular physical activity. In this way, physically active people after physical effort reach significantly lower heart rate values and more quickly restore the heart rate they have at rest.

Physical fitness can also be assessed based on the value of maximum oxygen uptake (VO_2 max) from the blood. The possibility of maximum oxygen uptake is limited by oxygen delivery to the active tissue. Blood oxygen delivery can be calculated as the product of blood flow through the muscles and the oxygen content of the arterial blood - saturation. Therefore, if one of these two factors is disturbed, the VO_2 max and the degree of physical endurance will decrease, which is why the measurement of blood oxygen saturation is of great importance in physically active people. Physiological oxygen saturation values range from 97% to 99%.

The aim of this paper was to compare certain anthropometric characteristics of physically active and physically inactive students, as well as to compare the values of heart rate and blood oxygen saturation at rest and after physical effort between these two groups of subjects.

METHODS

The research includes 40 male students aged 19 to 23 (20 physically active and 20 physically inactive) and 20 female students aged 19 to 23 (10 physically active and 10 physically inactive). Trained respondents are students who actively play sports and train an average of 10 hours a week, while the physically inactive group consists of students who did not engage

in physical activity for more than 2 hours a week. All subjects were thoroughly acquainted with the procedure and objectives of the research and signed their consent to be tested in the Laboratory for Sports Medicine and Exercise Therapy.

All subjects first had their body height (BH) measured in centimeters using a standard laboratory height meter (Seca 214 Portable Stadiometer, Cardinal Health, USA). With the help of a body composition analyzer (InBody 230 Body Composition Analyzer, Seoul, Korea), body mass (BM) expressed in kilograms, recalculated Body Mass Index (BMI), body fat percentage (%BF), and muscle mass expressed in kilograms were measured.

In addition to measuring anthropometric parameters, heart rate and blood oxygen saturation at rest were measured for all subjects. After that, the subjects were subjected to physical activity in the form of 20 squats in 20 seconds, after which their heart rate and blood oxygen saturation were immediately measured again. Measurements were made using a pulse oximeter.

All statistical analyzes were performed in SPSS26 (Statistical package for social sciences 26). In order to compare the data, standard descriptive statistics methods were used, and they are presented as arithmetic mean ± standard deviation. One-Way ANOVA test was used for data processing, in which a statistically significant difference was considered at the $p<0.05$ level.

RESULTS and DISCUSSION

The values of muscle mass (active-42.79kg, inactive-37.23kg) and percentage of body fat (%BF; active-14.995%, inactive-21.34%) are statistically significantly different in male subjects ($p<0.05$) (Table 1). The percentage of body fat (%BF) was significantly higher in the group of physically inactive male students, while their muscle mass values were significantly lower compared to the group of physically active male subjects. The values of the examined anthropometric parameters between physically active and inactive female students do not show a statistically significant difference ($p>0.05$), except for the value of muscle mass (active-28.42kg, inactive-23.17kg), which is significantly higher in the physically active group (Table 2).

Table 1: *Anthropometric parameters of male students; physically active (n=20) vs. physically inactive (n=20)*

Students / Variable	Physically active	Physically inactive	Active/inactive
	value ± SD	value ± SD	p - value
Body mass [kg]	87,931 ± 11,610	83,770 ± 11,199	1
Body height [cm]	187,400 ± 6,793	182,450 ± 5,596	0,065

BMI [%]	24,990 ± 2,521	25,179 ± 3,181	1
Muscle mass [kg]	42,790 ± 4,542	37,230 ± 5,059	0,001
Body fat percentage [%]	14,995 ± 7,399	21,340 ± 6,419	0,014

* p value determines the statistical significance of the differences, p<0.05 - the difference is statistically significant, otherwise the difference is not statistically significant

Table 2: *Anthropometric parameters of female students; physically active (n=10) vs. physically inactive (n=10)*

Students / Variable	**Physically active**	**Physically inactive**	**Active/inactive**
	value ± SD	value ± SD	p - value
Body mass [kg]	69,77 ± 10,618	59,43 ± 4,804	0,19
Body height [cm]	174,00 ± 5,558	166,40 ± 5,016	0,036
BMI [%]	23,06 ± 3,495	21,46 ± 1,415	1
Muscle mass [kg]	28,42 ± 2,487	23,17 ± 1,819	0,041
Body fat percentage [%]	25,82 ± 6,155	28,43 ± 2,735	1

* p value determines the statistical significance of the differences, p<0.05 - the difference is statistically significant, otherwise the difference is not statistically significant

The measured values of oxygen saturation at rest (men: 98.3% vs. 98.4%; women: 98% vs. 97.9%) and after physical effort (men: 97.5% vs. 98.2%; women: 97.9% vs. 97.7%) do not show statistically significant difference (p>0.05) between physically active and physically inactive respondents of both sexes. Heart rate values measured at rest (men: 81.9 vs. 102.6; women: 74.1 vs. 92.45) and after physical effort (men: 112.7 vs. 149.8; women: 103.5 vs. 129.95) show a statistically significant difference (p<0.05) between physically active and physically inactive students of both sexes (Table 3 and Table 4). Heart rate measured at rest has lower values in the group of physically active students of both sexes, while higher values of heart rate after physical effort were recorded in physically inactive students of both sexes.

Table 3: *Values of heart rate and blood oxygen saturation before and after physical activity in female students; physically active (n=10) vs. physically inactive (n=10)*

Students / Variable	Physically active	Physically inactive	Active/inactive
	value ± SD	value ± SD	p - value
Heart rate before physical activity [beat/min]	74,1 ± 14,654	92,45 ± 20,072	0,006
Heart rate after physical activity [beat/min]	103,5 ± 18,574	129,95 ± 17,686	0,006
Oxygen saturation before physical activity [%]	98,0 ± 0,918	97,90 ± 0,968	1
Oxygen saturation after physical activity [%]	97,9 ± 0,852	97,70 ± 0,979	1

* p value determines the statistical significance of the differences, p<0.05 - the difference is statistically significant, otherwise the difference is not statistically significant

Table 4: *Values of heart rate and blood oxygen saturation before and after physical activity in male students; physically active (n=20) vs. physically inactive (n=20)*

Students / Variable	Physically active	Physically inactive	Active/inactive
	value ± SD	value ± SD	p - value
Heart rate before physical activity [beat/min]	81,9 ± 15,927	102,6 ± 13,866	0,047
Heart rate after physical activity [beat/min]	112,7 ± 28,095	149,8 ± 19,498	0,001
Oxygen saturation before physical activity [%]	98,3 ± 0,675	98,4 ± 0,699	1
Oxygen saturation after physical activity [%]	97,5 ± 0,850	98,2 ± 0,919	0,54

* p value determines the statistical significance of the differences, p<0.05 - the difference is statistically significant, otherwise the difference is not statistically significant

From the results obtained in this study, a difference in body composition can be observed between physically active and inactive students, with the fact that various parameters differ between these two groups in

males and females. In male students, a statistically significant difference was observed between the percentage of body fat. We know that obesity and a sedentary lifestyle are extremely important risk factors for the development of ischemic heart disease, diabetes mellitus type 2 and many other chronic diseases. Adipose tissue adapts to the effect of an unbalanced diet and lack of physical activity by creating new adipocytes, as well as hypertrophy of existing ones (9). Based on this, it can be understood why significantly higher values of body fat percentage were observed in the group of physically inactive male students. On the other hand, in female students, the values of body fat do not differ much between the two investigated groups, probably due to the greater commitment of the female gender to health, diet and physical appearance. The parameter that was significantly higher in the group of physically active students of both sexes is muscle mass expressed in kilograms. Based on the data obtained in the research, which are lower values of muscle mass in the group of physically inactive students, we can conclude that physical activity has a great influence on the muscle percentage in the body. Under the influence of muscle contractions, the capillaries fill up and the amount of blood passing through them increases due to the increased metabolic demands of the active muscle. This contributes to better blood circulation and muscle nutrition, which increases the volume of muscle fibers, thus the muscles, increases muscle strength and leads to more economical muscle work. The results obtained in this study concur with the results of the study conducted by L. Radu (1), which compares anthropometric characteristics between physically active and physically inactive persons. The study was performed on 20 handball and 16 volleyball players and on 21 healthy physically inactive subjects. In addition to the parameters mentioned in our study, this study also observed a statistically significant difference in height between physically active and inactive subjects, which was not the case in our study. This can be attributed to the selection of professional athletes who play volleyball, while the physically active group in our study consisted of students who play different sports for a maximum of 10 hours a week. In addition to maintaining optimal body and muscle mass, physical activity also contributes to the structure and maintenance of bones and joints, strengthening the immune system and psychological well-being (10). According to the goal of exercise, we distinguish between stretching exercises (leading to improvement of range of motion), aerobic exercise (improving cardiorespiratory endurance) and anaerobic exercise (improving muscle strength and endurance). In relation to mechanical action, we distinguish between static exercise that leads to the development of large muscle mass, with or without a change in muscle length (gymnastics, weight lifting, wrestling) and dynamic exercise that leads to a change in muscle length and to the movement of joints (fast walking, running, swimming). Most exercises have a combination of these two components. According to ACSM (The American College of Sports Medicine), dosed aerobic dynamic exercise has the best health effects.

The results related to the heart rate value obtained in this study are in support of the results obtained in previous studies that dealt with the same topic, as the study conducted in 2017 on 30 physically active and 30 physically

inactive students aged 18 to 22 (11). Subjects were measured BMI, heart rate and VO_2 max at rest and after physical exertion in the form of a twelve-minute fast walk. Resting heart rate values are significantly lower in physically active persons, while the increase in heart rate is significantly higher in physically inactive persons, which coincides with the results obtained in this study. The reason for such results can be attributed to the following facts. In untrained persons, the minute volume during physical activity is about 20-25 L/min, while in athletes this value can reach 40 L/min (7). The difference between the minute volume of the heart at rest and the maximum volume that the heart can pump, as is the case during physical exertion, is called cardiac reserve. Cardiac reserve allows the heart to meet the demands of peripheral tissues during increased muscle work. From the above, it can be concluded that the heart reserve in sportsmen is significantly higher than in physically inactive people. Another difference between athletes and untrained individuals is that at rest, athletes have a lower heart rate, higher end-systolic volume, and higher stroke volume. Therefore, athletes can achieve a greater increase in cardiac output without an increase in heart rate, which is not the case in untrained individuals (7).

CONCLUSION

The results of this research show that engaging in physical activity in both sexes leads to an increase in muscle mass and a decrease in heart rate both at rest and after physical exertion. In male students, physical activity also affects the percentage of body fat in the form of its significant reduction. In the end, it can be concluded that physical activity has a positive effect on certain anthropometric characteristics as well as on the state of the cardiovascular system, which contributes to the improvement of the general condition and the removal of potential factors for the emergence of chronic diseases responsible for a high level of morbidity and mortality in the general population.

REFERENCES

1. Radu L-E, Popovici I-M, Puni A-R. (2015). Comparison of Anthropometric Characteristics Between Athletes and Non-athletes. Procedia - Soc Behav Sci.,191:495–9.
2. Mazić S, Lazović B, Đelić M, Suzić Lazić J, Aćimović T, Brkić P. (2014). Body composition assessment in athletes: a systematic review. Med Pregl, 67(7–8):255–60.
3. Sallis JF, Floyd MF, Rodríguez DA, Saelens BE. (2012). Role of built environments in physical activity, obesity, and cardiovascular disease. Circulation, 125(5):729–37.
4. Gill JMR, Cooper AR. (2008). Physical activity and prevention of type 2 diabetes mellitus. Sport Med, 38(10):807–24.
5. Press V, Freestone I, George CF. (2003). Physical activity: The evidence of benefit in the prevention of coronary heart disease. QJM An Int J Med, 96(4):245–51.
6. Đorđević A. (2005). Rekreacija kao način savremenog življenja. Sport Med, 5(2):54–78.
7. Đurić D, Kojić Z, Lončar-Stevanović H, Mazić S, Maširović-Drašković G, Nešić D, et al. (2013). Fiziologija za studente medicine - odabrana poglavlja II deo. Medicinski fakultet

Univerziteta u Beogradu, CIBID - Centar za izdavačku, bibliotečku i informativnu delatnost, Beograd.
8. Lahiri MK, Kannankeril PJ, Goldberger JJ. (2008). Assessment of Autonomic Function in Cardiovascular Disease. J Am Coll Cardiol, 51(18):1725–33.
9. Coelho M, Oliveira T, Fernandes R. (2013). State of the art paper Biochemistry of adipose tissue: an endocrine organ. Arch Med Sci, 2:191–200.
10. Ostojić S, Stojanović M, Veljović D, Stojanović M, Međedović B, Ahmetović Z. (2009). Fizička Aktivnost i Zdravlje: Definicija problema, savremena zapažanja i preporuke. TIMS Acta, 3:1–13.
11. Sen Sarma A. (2017). A Comparative Study of Selected Physiological Variables Between active and sedentary college students. Int J Phys Educ Sport Heal, 4(2):100–2.

Anthropometric Differences Between Freedivers and Spearfisherman

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ABSTRACT.

This study aimed to determine the differences between spearfisherman and freedivers in anthropometrical indices. The sample of participants included 19 divers (10 spearfisherman (SF)); 9 freedivers (FD)). Along with age and training experience, used variables were anthropometric measurements: body mass, body height, seated body height, arm span, leg length, elbow diameter, fist width, knee diameter, foot width, foot length, body fat, upper arm girth, chest girth, abdomen girth, upper leg girth, lower leg girth. Results showed that SF and FD do not differ significantly in any of the measured variables, apart from abdomen girth (p=0.03). SF tend to have significantly higher abdomen girth (92,27±9,97), than FD (82,73±7,51). Therefore, this result may be influenced by the systematic training that FD are doing to prepare for official competitions. Also, there is a difference in the mean age of groups which could also influence the mentioned anthropometrical indices. Spearfisherman are older (40.60±9.69 years) than freedivers (35.33±7.65 years). The results imply that both FD and SF have similar anthropometrical adaptations to a specific environment of breath-hold diving activity. Future studies should include a larger number of participants to get a better insight into the differences and selection criteria.

Keywords: breath-hold diving, apnea, morphology, divers, anthropometric indices, adaptation

INTRODUCTION

Holding your breath for as long as possible underwater. Swimming underwater in a pool as far as possible while holding your breath. Diving deep into the sea and getting back up on a single breath. Classic challenges, known from children's play and tests of manhood, outlining the basic disciplines in the sport of freediving where divers explore how long or deep they can go underwater without assisting air. Current world records are static breath hold for 11 min and 35 s, 301 m underwater in the pool with monofin, and -133 m into the deep (and back up) with monofin, and 214 m Herbert Nitch in no-limit competition. Because of the obvious risk of drowning that arises when the human body is submerged in the aquatic world, freediving is often categorized as an extreme sport (Strandvad, 2018). Freediving is a sport in which an individual dive by holding his/her breath underwater. The performance of the fredivers is related to physiological and psychological limits of the athlete (Alkan & Akış, 2013), which is common in other sports. The physiological aspect is always the main subject when speaking about sports. Marathon runner doesn't have the same physiological characteristics as powerlifter. In each sport, demands are different so athletes that make the best results in the sports usually have similar physiological features. That's why we can say tall people play basketball (not all the players are tall but generally speaking taller people

have an advantage). For SF and FD having a good respiratory system and blood supply is important. Having well trained body is important but psychological control of the body is what makes freediver successful. Shooting last penalty, saving a goal, trying to dive just little bit more all have different types of psychological demands. Like in other sports divers needs to be psychologically prepared to face life threatening situations in almost every dive. One of the most important things is to have mental toughens to stay calm and relaxed under water. Making any rush and panic moves take effect on the result so just like in other sports having physiologically gifted and psychologically prepared athlete is the goal if freediver wants to be safe and successful (Lourenço, 2018). Enhancing human apneic diving capacity, as well as that of other diving mammal, is determined by the total aerobic and anaerobic metabolic stores, the asphyxia tolerance, and the rate at which the resources are used, i.e., metabolic rate (Schagatay, 2009). While the aerobic store is usually considered to be the major determinant of breath- hold diving ability, anaerobic resources clearly affect the maximal diving capacity of a species (Rodríguez-Zamora et al., 2018). During voluntary apnea, oxygen (O2) is mobilized from finite stores in the lungs, blood and other tissues, while the cardiovascular diving response restricts blood flow to selected regions and reduces heart rate and cardiac output. At the same time, the arterial tension of carbon dioxide (PaCO2) increases until a certain point that causes a stimulation of respiration, which over- rides the voluntary inhibition and restarts breathing. During resting apnea, blood flow is directed mainly toward the brain and heart, while the rest of the organism receives a limited blood flow (Rodríguez-Zamora et al., 2018).

Spearfishing is one of the oldest fishing techniques and can be broadly defined as the pursuing and catching of fish underwater without the aid of artificial breathing devices. It involves the use of harpoon gear that depends solely on the physical strength of the diver holding his breath. The spearfisherman is thus restricted to shallow waters and can be highly selective, targeting only certain species and sizes and avoiding the negative effects of other fishing techniques such as bycatch, loss of gear, or damage to habitat (Jelić Mrčelić et al., 2023). Spearfisherman main goal is to catch a fish. In order to do that he needs to first find a fish and then sneak up on her. Spearfisherman go up and down many times while freedivers are preparing themselves for longest or deepest dive. Whole training is about pushing to the limits so for that reason they don't have as many dives as spearfisherman. Therefore, we can say the biggest difference between these two sports is that freedivers have less dives per session but are getting their body to the limits. On the other hand, spearfisherman have more dives per session and have less pressure on the body because they dive in shallower waters.

A literature review covering 1971-2001 indicated there were 84 200 articles on fishing and only 145 of these had any reference to spearfishing. The number of relevant articles is much fewer (Smith & Nakaya, 2003). On the other hand, freediving has been more researched and studied. Scientific literature about freediving is more focused on individual factors that freediving has on a human body such as: myoglobin saturation, cardiovascular responses or even psychological demands of freediving. Our team chose this subject because there are no comparative scientific articles about these two similar BHD activities considering anthropometrical characteristics of

these two groups of athletes. Anthropometrical indices can tell us a lot about sport selection criteria. There is a lot of people who train gymnastics but only few make it to the top. When speaking about that top we can see a pattern forming. Usually top-level gymnastics athletes are short with low body fat. That's logical if we think what gymnastics athletes have to do with their body strength. Additionally, water polo players are usually taller with more body fat. There are some people who genetically have more advantage in certain sports because their body composition is suitable for demands of the sport. In team sports we can even see different anthropometrical indices among different positions played in the game.

Literature review showed small number of studies comparing spearfisherman and freedivers in anthropometric indices. Therefore, the main aim of this study is to determine the possible differences between freedivers and spearfisherman. We hypothesized that there should be some differences between the groups mainly because of the different trainings that the athletes are using to perform at their best. Also, there is an environmental difference were the athletes compete, which can be seen through adaptation of morphology.

METHODS

Participant

The sample of participants included 19 male athletes (9 freedivers, and 10 spearfishermen). Freedivers chronological age was 35.33±7.65 years, body mass 79.80±9.90 kg, and height 183.56±5.43 cm. Spearfisherman chronological age was 40.60±9.69 years, body mass 88.91±13.02 kg, and height 186.50±7.99 cm. Participants' training experience was 11.89±9.72 years (spearfisherman, 15.90±11.45 years; freedivers, 7.44±4.75 years). Participants did not have any illness or medical condition that may have prevented them from performing tests. They were informed about the procedures and purpose
of the study and signed informed consent before the investigation began. The study was conducted following the declaration of Helsinki, and the Ethical Board of the Faculty of Kinesiology, University of Split, Croatia (Ethical board number 2181-205-02-05-22-035).

Variables and procedure

General variables included: age and training experience. Anthropometric measurements included: body mass (BM), body height (BH), seated body height (SBH), arm span (AS), leg length (LL), elbow diameter (ED), fist width (FW), knee diameter (KD), foot width (FW), foot length (FL), body fat (BF), upper arm girth (UAG), chest girth (CG), abdomen girth (AG), upper leg girth (ULG), lower leg girth (LLG). The body composition (BM and BF) of the participants was assessed by the body composition analyzer TANITA MC780MA (Japan). BH, AS, LL, and SBH were measured by using measuring tape, the same as the girths of the aforementioned body segments (UAG, CG, AG, ULG, LLG). Diameters were measured with a segmometer.

Statistical analysis

Descriptive statistics included calculation of arithmetic mean and standard deviation, minimal and maximal results. The Kolmogorov-Smirnov test was calculated to estimate the normality of distribution in each variable. Differences between groups of

participants were assessed by using a t-test for independent samples. All statistical analysis was done in Statistica v13.00 software.

RESULTS and DISCUSION

The results of descriptive statistics are presented in Table 1. According to the Kolmogorov-Smirnov test calculation, it can be seen that all variables have a normal distribution and are therefore suitable for application of parametric statistical methods.

Table 1. Descriptive parameters of measured variables, on the total sample of participants (N=19)

Variable	*AS*	*Min*	*Max*	*SD*	*Max D*	*K-S p*
Age (years)	*38.11*	*21.00*	*58.00*	*8.96*	*0.08*	*p > .20*
Training experience (years)	*11.89*	*1.00*	*36.00*	*9.72*	*0.15*	*p > .20*
Body mass (kg)	*84.59*	*65.00*	*115.80*	*12.26*	*0.09*	*p > .20*
Body height (cm)	*185.11*	*175.00*	*203.00*	*6.88*	*0.13*	*p > .20*
Seated body height (cm)	*92.94*	*81.00*	*103.00*	*5.38*	*0.14*	*p > .20*
Arm span (cm)	*183.45*	*82.00*	*205.00*	*25.70*	*0.32*	*p < .05*
Leg length (cm)	*96.32*	*88.00*	*112.50*	*5.47*	*0.19*	*p > .20*
Elbow diameter (cm)	*7.05*	*6.30*	*8.10*	*0.48*	*0.15*	*p > .20*
Fist width (cm)	*10.80*	*9.80*	*12.10*	*0.64*	*0.10*	*p > .20*
Knee diameter (cm)	*10.09*	*8.70*	*12.10*	*0.69*	*0.17*	*p > .20*
Foot width (cm)	*10.59*	*9.80*	*11.80*	*0.51*	*0.13*	*p > .20*
Foot length (cm)	*27.29*	*23.40*	*29.50*	*1.62*	*0.22*	*p > .20*
Body fat (%)	*14.93*	*7.80*	*23.00*	*4.40*	*0.14*	*p > .20*
Upper arm girth (cm)	*31.63*	*27.50*	*35.50*	*2.30*	*0.18*	*p > .20*
Chest girth (cm)	*99.88*	*88.10*	*114.00*	*6.69*	*0.12*	*p > .20*
Abdomen girth (cm)	*87.75*	*72.90*	*111.60*	*9.93*	*0.14*	*p > .20*
Upper leg girth (cm)	*53.42*	*45.80*	*60.50*	*3.72*	*0.09*	*p > .20*
Lower leg girth (cm)	*38.13*	*34.40*	*49.20*	*3.36*	*0.26*	*p < .15*

***Legend**: **AS**-arithmetic mean; Min-minimum result; Max-maximum results; **SD**-standard deviation; **Max D**-test value of Kolmogorov-Smirnov test; **K-S p**-Kolmogorov-Smirnov test*

Table 2. shows the results of differences between freedivers and spearfisherman in all measured variables. Analysis of the results shows that the groups differ significantly only in variable abdomen girth (AG) (p=0.03). In AG spearfisherman have higher results (92.27±9.97 cm) than freedivers (82.73±7.51 cm). Whereas, all other measured variables do not have statistically significant differences (p>0.05). However, the training experience of participants tends to become statistically significant at the value of p=0.06 (spearfisherman, 15.90±11.45 years; freedivers, 7.44±4.75 years).

Table 2. Differences between groups in measured variables, on the total sample of participants (N=19)

Variable	*Spearfisherman (N=10)*		*Freedivers (N=9)*		*t-value*	*p*
	AS	*SD*	*As*	*SD*		
Age (years)	*40.60*	*9.69*	*35.33*	*7.65*	*1.30*	*0.21*
Training experience (years)	*15.90*	*11.45*	*7.44*	*4.75*	*2.06*	*0.06*

Body mass (kg)	*88.91*	*13.02*	*79.80*	*9.90*	*1.70*	*0.11*
Body height (cm)	*186.50*	*7.99*	*183.56*	*5.43*	*0.93*	*0.37*
Seated body height (cm)	*93.00*	*6.28*	*92.87*	*4.54*	*0.05*	*0.96*
Arm span (cm)	*188.70*	*8.34*	*177.61*	*36.54*	*0.94*	*0.36*
Leg length (cm)	*97.00*	*7.06*	*95.56*	*3.16*	*0.56*	*0.58*
Elbow diameter (cm)	*7.20*	*0.56*	*6.89*	*0.31*	*1.47*	*0.16*
Fist width (cm)	*10.98*	*0.63*	*10.60*	*0.62*	*1.32*	*0.20*
Knee diameter (cm)	*10.09*	*0.60*	*10.10*	*0.82*	*-0.03*	*0.98*
Foot width (cm)	*10.49*	*0.41*	*10.71*	*0.61*	*-0.94*	*0.36*
Foot length (cm)	*27.35*	*1.78*	*27.22*	*1.52*	*0.17*	*0.87*
Body fat (%)	*16.49*	*3.86*	*13.20*	*4.53*	*1.71*	*0.11*
Upper arm girth (cm)	*31.88*	*2.08*	*31.34*	*2.61*	*0.50*	*0.63*
Chest girth (cm)	*100.79*	*6.58*	*98.88*	*7.06*	*0.61*	*0.55*
Abdomen girth (cm)	*92.27*	*9.97*	*82.73*	*7.51*	*2.33*	*0.03**
Upper leg girth (cm)	*54.15*	*3.50*	*52.61*	*4.00*	*0.89*	*0.38*
Lower leg girth (cm)	*38.99*	*4.40*	*37.18*	*1.32*	*1.19*	*0.25*

Legend: AS**-arithmetic mean; **Min**-minimum result; **Max**-maximum results; **SD**-standard deviation**, p-level** of significance; **-statistically significant result at p<0.05*

The main aim of this study was to determine the possible differences between FD and SF. Following that, the obtained results imply that the groups do not differ significantly in any of the measured variables, apart from the abdomen girth. Reason to that might be similar adaptation of the body to these two sports. Talking in general, demands of freediving and spearfishing are similar, that's why we can think that muscle and bone structure adopt similarly. These similarities are influenced by the underwater performance. According to evidence (Schagatay, 2009), trained freedivers have greater oxygen storage available than untrained; thus, whereas a 70-kg person can store 1996 ml of oxygen (820 ml in the lungs, 880 ml in the blood and the rest in other tissues), it is estimated that an elite diver with similar anthropometry is capable of storing up to 3200 ml of oxygen in the body (1650 ml in the lungs, 1100 ml in the blood and the rest in other tissues). Also, according Škarić-Jurić et al. (2003) general population of Croatia (176.10±7.00 cm) tend to be smaller than our group of divers (185.11±6.88 cm). Furthermore, the height was shown as a good predictor of apnea indoor performance. It is thought to be that the highest divers have an anthropometric advantage that gives them, in addition to a known increased swimming efficiency (Zampagni et al., 2008), a greater underwater swimming efficiency. Looking further in results: age, training experience, body mass and body fat show some differences that need to be explained. Taken in average our group of SF is 5 years older than group of FD. There is also difference in training experience which can be explained trough the age difference. SF are in average older than FD and that might be the reason why they have more training experience.

Differences shown in abdomen girth (p=0.03), is that SF tend to have significantly higher abdomen girth (92,27±9,97), than FD (82,73±7,51).

Results showed that average of SF weight is 88.91kg, while average FD weight is 79.80kg. That goes well with information that SF in average have 3% more body fat than FD. These last two information (body fat and body mass) are connected with our second finding of research which is the only significant difference

we found. We can see that our group of SF have in average 10 cm bigger abdomen girth than FD. There are a few theses to this. First of all, spearfishing is seasonal sport and a lot of people do it for recreational purposes. SF have to rely on weather conditions. During the cold days SF body fat helps them stay warm. So, having more body fat in spearfishing can also be considered good. Depending on weather conditions makes periodic and consistent training hard. Having shown the differences in body mass and body fat can also explain abdomen girth difference. Abdomen area is area that stores a lot of body fat. Having bigger body fat and body mass it is logical to expect bigger abdomen girth. According to previous research environmental conditions, fitness, body composition, nutritional status, psychophysical relaxation or diving reflex are several factors that may influence in the individual metabolic rate during apnea (Fernández et al., 2015; Lindholm et al., 2007). Also, age and training experience can give us little bit more information about abdomen girth difference. Our group of SF is a bit older than FD so taking into consideration that our group of SF is in this sport many years but it is seasonal and recreational. FD are doing systematic breathing trainings and train all year round. Which means they have systematic training program. That tells us that FD have more athletic body composition.

CONCLUSION

This is one of the first study that has taken comparative approach on spearfishing and freediving. Literature show lack of such studies most probably because of unpopularity of the sports and lack of interest. It can be concluded that all measurements show similar adaptations of the to these two sports. However, freedivers in our study showed more athletic body composition. Future studies need to focus on larger group of breath-hold athletes and examine more precisely the anthropometrical adaptations to these activities.

REFERENCES

1. Alkan, N., & Akış, T. (2013). Psychological characteristics of free diving athletes: a comparative study. *International Journal of Humanities and Social Science*, *3*(15), 150-157.
2. Fernández, F., Patrician, A., Lodin-Sundström, A., & Schagatay, E. (2015). Predicting static and dynamic apnea performance in elite divers using a 2-minute static apnea test. EUBS conference, Amsterdam 19-22 August, 2015,
3. Jelić Mrčelić, G., Slišković, M., & Soldo, A. (2023). An Assessment of Spearfishing Catches along the Eastern Adriatic Coast. *Fishes*, *8*(7), 346.
4. Lindholm, P., Conniff, M., Gennser, M., Pendergast, D., & Lundgren, C. (2007). Effects of fasting and carbohydrate consumption on voluntary resting apnea duration. *European journal of applied physiology*, *100*, 417-425.
5. Lourenço, S. M. d. S. (2018). The psychology of freediving: psychological strategies used by elite freedivers.
6. Rodríguez-Zamora, L., Engan, H. K., Lodin-Sundstrom, A., Schagatay, F., Iglesias, X., Rodríguez, F. A., & Schagatay, E. (2018). Blood lactate accumulation during competitive freediving and synchronized swimming. *Undersea and Hyperbaric Medicine*, *45*(1), 55-63.

7. Schagatay, E. (2009). Predicting performance in competitive apnoea diving. Part I: static apnoea. *Diving Hyperb. Med*, *39*(2), 88-99.
8. Smith, A., & Nakaya, S. (2003). Spearfishing-is it ecologically sustainable? *Spearfishing-is it ecologically sustainable?*(67), 19-22.
9. Strandvad, S. M. (2018). Under water and into yourself: Emotional experiences of freediving contact information. *Emotion, Space and Society*, *27*, 52-59.
10. Škarić-Jurić, T., Ginsburg, E., Kobyliansky, E., Malkin, I., Smolej Narančić, N., & Rudan, P. (2003). Complex segregation analysis of body height, weight and BMI in pedigree data from Middle Dalmatia, Croatia. *Collegium antropologicum*, *27*(1), 135-149.
11. Zampagni, M. L., Casino, D., Benelli, P., Visani, A., Marcacci, M., & De Vito, G. (2008). Anthropometric and strength variables to predict freestyle performance times in elite master swimmers. *The Journal of Strength & Conditioning Research*, *22*(4), 1298-1307.

Prevalence of Self-Estimated Functional Inability in Senior Water Polo Players

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ABSTRACT

Water polo is an extremely demanding sport that takes place in the water medium. It is this characteristic that makes water polo, as well as its structural components, different from other team sports. The occurrence of injuries and pain in certain parts of the body are everyday obstacles for both athletes and coaches. The amount and intensity of the game itself, in which different kinesiological activities are alternated, as well as strenuous schedules of competing, form a fertile ground for the occurrence of injuries, and acute and chronic pain. The aim of this study was to determine the prevalence of self-assessed occurrence of pain in senior water polo players. In the current paper, by using a modified SEFIP questionnaire, the occurrence of pain in individual parts of the body was detected in 45 senior water polo players from the city of Split. Looking at the results, most respondents reported pain in the neck, upper back and shoulders, which can be attributed to the water polo style of swimming as the main technique for movement inside the playground. This technique, in combination with classic swimming techniques, puts a heavy load on exactly these regions of the body. Also pain in the lower back and knee joint was detected, which could be attributed to switching training from the water to the gym, as these body parts are specifically subjected to load and pressure. Findings of the study give guidelines to coaches and athletes for the training process on which regions of the body should be paid more attention t in kinesiological treatments and transformation in order to preserve health and extend a productive sports career.

Keywords: musculo-skeletal pain, professional sport, aquatic activities, modified SEFIP questionnaire

INTRODUCTION

Water polo as a team water sport, due to its structural characteristics and kinesiological and anthropological requirements, is an extremely demanding activity. If you add to this the amount and intensity of contact in the game, as well as a strenuous schedule of competitions, there is a potential for the occurrence of various injuries, which can result in the development of acute and chronic pain conditions in athletes. Authors Franić, Ivković and Rudić (2007) state that water polo as a sport is a combination of swimming, throwing and contact like the one in martial arts, interspersed with intensive anaerobic intervals. Also, a review of previous research found that water polo combines bursts of high-intensity effort, endurance, throwing, and body contact with grappling. As a result, training frequently aims to improve a wide

range of abilities, including anaerobic power, aerobic fitness, muscle strength, and water polo-specific skills (Spittler & Keeling, 2016). Considering the above, many studies have dealt with giving instructions for the prevention and monitoring of injuries among water polo players (Mountjoy, Miller & Junge, 2019; Stromberg, 2017).

Therefore, as prevention, it is necessary to detect the incidence of the mentioned conditions, both by type and by topological prevalence. Knowing vulnerable regions of the body can help coaches in preventing unwanted health conditions through planning, programming and implementation of training, either in the sphere of technical-tactical preparation, or in the field of fitness preparation of athletes.

The aim of this work is to determine the prevalence of self-assessed occurrence of pain in senior water polo players.

METHODS

The research was conducted on 45 elite senior water polo players from clubs in the city of Split. All respondents were healthy without any reported chronical aberrations. Research was conducted in 2023.

Previous studies used the Self-Estimated Functional Inability because of Pain (SEFIP) screening questionnaire to identify pain in specific topological regions (Reis-Júnior, Pinheiro, Protázio et al, 2021; Ramel, Moritz, & Jarnlo, 1999). The SEFIP test was used in numerous studies to examine the occurrence and intensity of pain in various fields of kinesiology, and as such represents a reliable instrument for the purposes of this study (Pinheiro, Fidelis-de-Paula-Gomes, Barros, Melo, Bassi-Dibai & Dibai-Filho, 2021; Jacobs, Cassidy, Côté, Boyle, Ramel, Ammendolia & Schwartz, 2017; A. Miletić, Kostić & Đ. Miletić, 2011; A. Miletić, Kostić, Božanić & Đ. Miletić, 2009). For the purposes of this study, a modified SEFIP test was used that identifies body regions in more detail and examines pain on the left and right side (Šitić & Dumanić, 2016; Jelaska, Grgantov & Lukas, 2013). The SEFIP-sport is composed of 14 items, with responses on a 5-point Likert scale, which ranges from 0 representing no pain to 4 representing severe pain causing inability to train (Kalatakis-Dos-Santos, de Paula Gomes, Pontes-Silva, Mendes, de Oliveira Simões, Gonçalves & Dibai-Filho, 2022). In the modified version, there are a few more items that involve the left and right side of the body.

As part of data processing, the parameters of descriptive statistics were determined, including mean, standard deviation, median, minimal value, maximal value, skewness and kurtosis. Testing the normality of the data distribution was performed using the Kolmogorov-Smirnov test. Frequencies and percentage values were determined for each individual question of a modified SEFIP test, as a measure of the incidence of self-assessed inability for individual topological regions of the body. Statistica 12 software package was used for data processing.

RESULTS and DISCUSION

Table 1: Descriptive statistics

	N	Mean	Median	min	Max	SD	α_3	α_4	Max d
Total score	45	6.36	6	2	17	3.05	1.29	2.38	0.169

Critical values $D_{(n=45,\ \alpha=0.05)} = 0.198$

Table 1 shows the results of descriptive statistics for the cumulative score of the modified SEFIP questionnaire. The respondents scored an average of 6.36 points with a standard deviation of 3.05. The value of skewness (α_3=1.29) indicates a positive asymmetry of data distribution, that is, grouping of data in the zone of lower values, while the value of kurtosis (α_4=2.38) indicates a slight platykurtic distribution.

Testing the normality of data distribution was performed using the Kolmogorov-Smirnov test. Since the value Max d=0.169 does not exceed the critical value of the KS-test (D=0.198) for the sample size N=45 and the significance level α=0.05, the obtained distribution can be considered normal.

An insight into the results obtained using the SEFIP questionnaire (Table 2), showed that in the area of the cervical spine, 44.44% of respondents had reported moderate pain in the neck, while 15.56% had reported severe pain during training. This phenomenon can be attributed to a specific position of the neck, which is in hyperextension during the water polo swimming technique.

A large number of respondents reported moderate pain in the right shoulder 46.67% and left shoulder 40.00%. Severe pain was detected in five subjects, i.e., 11.11% of them, while in four of them or 8.89% avoided certain movements in the shoulder area of the dominant hand due to pain. Pain in the shoulder of the dominant hand can be explained by high forces when shooting and receiving the ball. Pain in the shoulder of the non-dominant arm can most likely be attributed to the decline in classical freestyle swimming technique due to fatigue during training, where the classical style of swimming, which has heavy loads on the shoulders, is used as a training operator.

Some respondents reported pain in the elbow area of the dominant hand, 28.89% that is, which can be explained by the loads on that joint when kicking and waving the ball, i.e. performing fakes. A few subjects felt pain in both elbow joints. This phenomenon can be explained by examining the data matrix, from which it is seen that it is about goalkeepers who get hit by the ball in the area of the elbow when defending.

Table 2: Modified SEFIP questionnaire

Topological region	It doesn't hurt at all		It hurts a little		I'm in a lot of pain, but I'm training		It hurts a lot, so I avoid certain movements		I can't train at all because of the pain	
	n	**%**	**n**	**%**	**N**	**%**	**n**	**%**	**n**	**%**
Neck	17	37.78	20	44.44	7	15.56	1	2.22	0	0
Right shoulder	15	33.33	21	46.67	5	11.11	4	8.89	0	0
Left shoulder	27	60.00	18	40.00	0	0	0	0	0	0
Right elbow	28	62.22	13	28.89	2	4.44	1	2.22	1	2.22
Left elbow	41	91.11	3	6.67	1	2.22	0	0	0	0
Right wrist	34	75.56	7	15.56	3	6.67	1	2.22	0	0
Left wrist	43	95.56	2	4.44	0	0	0	0	0	0
Right hand fingers	31	68.89	11	24.44	2	4.44	1	2.22	0	0
Left hand fingers	39	86.67	6	13.33	0	0	0	0	0	0
Upper back	26	57.78	14	31.11	4	8.89	1	2.22	0	0
Lower back	11	24.44	20	44.44	13	28.89	1	2.22	0	0
Right hip	42	93.33	1	2.22	2	4.44	0	0	0	0
Left hip	43	95.56	2	4.44	0	0	0	0	0	0
Right upper leg (front)	44	97.78	1	2.22	0	0	0	0	0	0
Left upper leg (front)	45	100	0	0	0	0	0	0	0	0
Right upper leg (back)	44	97.78	1	2.22	0	0	0	0	0	0
Left upper leg (back)	41	91.11	4	8.89	0	0	0	0	0	0
Right knee	34	75.56	10	22.22	1	2.22	0	0	0	0
Left knee	36	80.00	8	17.78	1	2.22	0	0	0	0
Right lower leg (bones)	44	97.78	1	2.22	0	0	0	0	0	0
Left lower leg (bones)	45	100	0	0	0	0	0	0	0	0
Right calf	44	97.78	1	2.22	0	0	0	0	0	0
Left calf	45	100	0	0	0	0	0	0	0	0
Right ankle	40	88.89	5	11.11	0	0	0	0	0	0
Left ankle	44	97.78	1	2.22	0	0	0	0	0	0
Right foot	45	100	0	0	0	0	0	0	0	0
Left foot	45	100	0	0	0	0	0	0	0	0

Also, the data showed that15.56% of water polo players felt moderate pain in the wrist of their right hand, as well as 24.44% reported pain in the fingers of the same hand. A similar phenomenon can be detected in left-handed people, whose number is smaller in the current study. Pain in the wrists and fingers most likely occurs due to frequent ball hits on the fingers and wrist, which leave microtraumas on the small joints.

Moderate pain in the upper back was detected in 31% of respondents, and severe pain in 8.89% during matches or training. This phenomenon can be explained by the position of the upper part of the spine when swimming in water polo style, as well as by the strain on the back muscles when performing strokes in

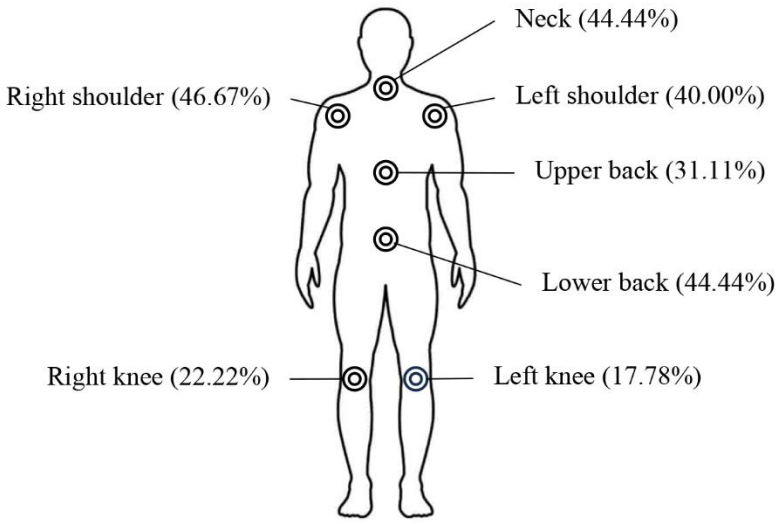
freestyle swimming. A large number of respondents complained of moderate pain in the lower back 44.44%, while 28.89% of respondents reported severe pain in the same region of the body but could perform tasks during training. It is possible to conclude that changes in body position from horizontal to vertical position during the game and the demands of training on dry land cause pain in this topological region of the body.

It is interesting that the majority of respondents did not report pain in the lower extremities such as upper leg, lower leg, calf or ankle, while 22.22% and 17.78% of them felt moderate pain in the right and left knee respectively. Due to the specificity of the knee joint and the transition from the water medium, in which players spend most of the time, to the gym on dry land, it is quite likely for the detected phenomenon to occur. The data also revealed that extremely strong pain appeared in certain parts of the body in some individuals, which points to acute and chronic injuries of certain players.

CONCLUSION

Conducted research detected critical topological regions in professional senior water polo players, susceptible to injuries and the development of pain. The mentioned neuralgic points refer primarily to the area of the cervical spine, shoulder and elbow of the dominant hand, and the upper and lower back regions (Figure 1). The causes of pain in these regions of the body can be attributed to the specifics of the water polo game as well as the training and competition regime.

Figure 1: Dominant neuralgic topological regions (moderate pain)



The obtained findings should serve coaches and athletes as a starting point in the planning, programming and implementation of training procedures with the aim of preventing injuries and the development of painful conditions in athletes. An approach to sports based on the aforementioned principles will create conditions not only for optimizing the results of the training process and prolonging the sports career, but above all, for the preservation and

improvement of health, which is a primary goal
of every kinesiological activity.

REFERENCES

1. Franić, M., Ivković, A., & Rudić, R. (2007). Injuries in water polo. *Croatian medical journal*, *48*(3), 281-288.
2. Jelaska, I., Grgantov, Z., & Lukas, T. (2013). Prevalence and topology of pain in professional male and female tennis players. *Scientific Journal of Sport and Physical Education*, 42.
3. Jacobs, C.L., Cassidy, J.D., Côté, P., Boyle, E., Ramel, E., Ammendolia, C., & Schwartz, I. (2017). Musculoskeletal injury in professional dancers: prevalence and associated factors: an international cross-sectional study. *Clinical Journal of Sport Medicine, 27*(2), 153-160.
4. Kalatakis-Dos-Santos, A.E., de Paula Gomes, C.A.F., Pontes-Silva, A., Mendes, L.P., de Oliveira Simões, G., Gonçalves, M.C., & Dibai-Filho, A.V. (2022). Fear of Return to Sport Scale (FRESS): a new instrument for use in injured professional or recreational athletes in rehabilitation. *Sport sciences for health*, 1-10.
5. Miletić, A., Kostić, R., & Miletić, Đ. (2011). Pain Prevalence Among Competitive International Dancers. *International journal of Athletic Therapy & Training 16*(1), 13-16.
6. Miletić, A., Kostić, R., Božanić, A., & Miletić, Đ. (2009). Pain Status Monitoring in Adolescent Dancers. *Medical problems of performing artists 24*(7), 119-124.
7. Mountjoy, M., Miller, J., & Junge, A. (2019). Analysis of water polo injuries during 8904 player matches at FINA World Championships and Olympic games to make the sport safer. *British journal of sports medicine, 53*(1), 25-31.
8. Pinheiro, C.A.B., Fidelis-de-Paula-Gomes, C.A., Barros, V.D.S., Melo, J.S.P., Bassi-Dibai, D., & Dibai-Filho, A.V. (2021). Self-Estimated Functional Inability because of Pain questionnaire for Brazilian workers with musculoskeletal pain: face and content validity. *Fisioterapia e Pesquisa, 27*, 299-305.
9. Ramel, E.M., Moritz, U., & Jarnlo, G.B. (1999). Validation of a pain questionnaire (SEFIP) for dancers with a specially created test battery. *Medical problems of performing artists, 14*(4), 196-203.
10. Dos Reis-Júnior, J.R., Pinheiro, J.S, Protázio, J.B, Pinheiro, C.A.B., Fidelis-de-Paula-Gomes, C.A., de Oliveira Pires, F., de Souza, S.A.R., Anselmo-E-Silva, C.I., da Silva Souza, C, Bassi-Dibai, D, & Dibai-Filho, A.V. (2021). Self-estimated functional inability because of pain questionnaire for athletes: a reliability and construct validity study. *J Chiropr Med 20*, 23–29.
11. Spittler, J., & Keeling, J. (2016). Water polo injuries and training methods. *Current sports medicine reports*, *15*(6), 410-416.
12. Stromberg, J. D. (2017). Care of water polo players. *Current sports medicine reports*, *16*(5), 363-369.

13. Šitić, K., & Dumanić, D. (2016). Topological regions and frequency of pain in young swimmers. *Acta Kinesiologica*, 29.

Performance Analysis of Junior Water Polo Players with Sport Specific Polygon; Preliminary Study

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ABSTRACT

This study aimed to determine the performance of junior water polo players by using a sport-specific polygon. The sample of participants included 9 water polo players (average age 16.70±1.06 years; body height 186.11±6.42 cm; body mass 81.18±7.30 kg; body fat percentage 14.14±2.95). Used variables were measured in resting state and in polygon (average force during 20 sec, shooting velocity, and 20-meter sprint). Also, the percentage to rank the participants was calculated in the manner that the result from the participant was divided by the maximal result of the group. Results showed that there is a significant difference obtained between shoot velocity in the resting state (71.40±5.17 km/h) and polygon (65.50±6.11 km/h). Also, a significant difference is seen between the 20-meter sprint (rest, 11.70±0.69 sec; polygon, 13.69±0.79 sec). Furthermore, correlation analysis showed that shooting velocity in a polygon has a significant positive correlation with average force (0.76) and shoot in rest (0.92). Also, there is a positive correlation between the 20-meter sprint in rest and in polygon (0.64). Apart, from that there is a negative relation between a 20-meter sprint in rest and in a polygon (-0.68), and between a 20-meter sprint in rest and shoot in the polygon (-0.80). The results imply that a polygon like this one can be a good predictor of sport-specific performance, especially for complex sports such as water polo. Furthermore, the differences between variables in rest and in polygon indicate that it is exhaustive and can mimic one complex of defense to offense in water polo match.

Keywords: dynamometer, shooting, swimming

INTRODUCTION

Water polo is one of the oldest Olympic sports, together with football, it was listed in the Olympic Games program since Paris 1900. Even doe, the rules of the game changed through the years, water polo remained a hard and demanding activity (Smith, 1998). The rules are that the playing field is located between two goals in a swimming pool, and the team consists of 6 players on the field and a goalkeeper. Playing positions in both attack and defense are center, two wings, two flats, and a point guard. The specificity of water polo transition from attack to defense, and likewise, is that the same players remain in their position. Like in handball rotation changes exist but are not commonly used (not in every single transition). Therefore, the assessment of specific performance is necessary to determine how well the players can endure these demands.

Sport-specific testing is becoming more and more popular in modern sports and is usually developed for the simulation of characteristic performances. The main idea of such tests is that they remake the real situation as it is in a sports match environment. It is commonly accepted that such tests are more useful than standard, laboratory, tests, for the evaluation of athletes' capabilities that are needed during a real match (Meckel et al., 2009). Also, they are useful for the selection and orientation of athletes (Sattler et al., 2012). Furthermore, there is good applicability of sport-specific tests for the determination of athletes playing position in the team (Kondrić et al., 2012; Melchiorri et al., 2009; Tan et al., 2009). Sport-specific tests are commonly used in many sports, however, there is a hypothesis that their usefulness in water sports could be really important. This is mainly because of the fact that there is a huge limitation in commonly used dry land tests for physical fitness (e.g., jumps, throws, sprinting, aerobic/anaerobic capacities) (Kondrić et al., 2012; Perić et al., 2012; Sajber et al., 2013).

However, sport-specific water polo tests are not that common, taking into consideration their reliability and validity. Furthermore, there are few previous studies that examined the capacities of swimming endurance and protocols for such tests (Melchiorri et al., 2009.; Mujika et al., 2006.; Tan et al., 2009). On the other hand, there is an evident lack of studies that look into motoric abilities tests specific to water polo (Gobbi et al., 2011; Platanou, 2005; Tan et al, 2010). The aforementioned studies mainly focused on one type of jump in water polo and apart from that they used other motoric water polo abilities (e.g., sprinting, throwing, precise ball handling, dynamometric force in eggbeater, etc.) Following all of that, this study aimed to determine the performance of junior water polo players by using a sport-specific polygon.

METHODS

Participants

The sample of participants included 9 water polo players (average age 16.70±1.06 years; body height 186.11±6.42 cm; body mass 81.18±7.30 kg; body fat percentage 14.14±2.95). At the time of the study, all participants had between 5 and 9 years of training experience and are members of one of the 3 best young water polo teams in Croatia. All participants trained regularly 10 to 15 hours per week, and they participated without any injuries or illnesses. The sample consisted of 5 different playing positions: goalkeeper (n=1), center (n=1), right flat (n=4), right-wing (n=2), left flat (n=1).

Variables and Procedures

Used variables were measured in resting state and in polygon (average force during 20 sec, shooting velocity, and 20-meter sprint). Also, the percentage to rank the participants was calculated in the manner that the result from the participant was divided by the maximal result of the group.

$$\%\ of\ rank\ in\ group = \frac{result\ of\ particiapnt}{Best\ result\ of\ the\ sample} * 100$$

Test 20-meter swimming started with a sound signal, similar to starting a sprint in a water polo game, without pushing the wall. The head of participants was kept above water (water polo crawl). For measuring the time of the sprint, the stopwatch was used.

The dynamometric test consisted of a 20-second eggbeater kick in the horizontal position, similar to that of a point guard when defending a center player. The participants were tied to the waist with

the belt that was connected to the dynamometer with the rope. The force was measured and evaluated with the dynamometer (PCE-FN, Pce systems). The data was processed with Matlab software to get the average force during the test.

The shooting test was done with the dominant hand, at a 6-meter distance from the radar. The test was repeated 3 times and the fastest results were obtained. The shooting velocity was measured by using a radar gun (Supido radar).

After measuring all of the tests at rest the participants did a polygon test. It mimics the one complex of defense to offense in a water polo match. The polygon was done in the manner that on sound signal the athlete did a 20-second eggbeater released the belt and started the 20-meter sprint. At the end of the sprint, the ball was thrown to them and they executed the shoot.

Statistical analysis

Statistical analysis included descriptive parameters (means, minimum and maximum result, and standard deviations). For the determination of possible differences, between the tests in rest and polygon, a t-test for dependent variables was used. For the determination of possible relation, Pearson's correlation was calculated.

All of the data were analyzed in statistics software, Statistica v13.

RESULTS and DISCUSSION

Table 1 shows the differences between measured variables in rest and polygon. The table demonstrates measured variables together with percentages that show the result in regard to the best result of the group.

Table 1. Differences between measured variables and calculated percentage in rest and in the polygon.

Variable	*AS*	*SD*	*t*	*p*
Average force 20 sec	*170.46*	*24.77*	*2.15*	*0.06*
Average force in polygon	*141.17*	*37.23*		
% Average force 20 sec	*81.49*	*11.84*	*2.19*	*0.06*
% Average force in polygon	*67.24*	*17.73*		
Shoot	*71.40*	*5.17*	*7.70*	*0.00**
Shoot in polygon	*65.50*	*6.11*		
% Shoot	*90.38*	*6.54*	*-0.63*	*0.54*
% Shoot in polygon	*91.37*	*5.20*		
20m	*11.70*	*0.69*	*-9.94*	*0.00**
20m in polygon	*13.69*	*0.79*		
% 20m	*92.67*	*5.26*	*0.98*	*0.35*
% 20m in polygon	*90.97*	*8.49*		

Legend: AS-arithmetic mean; SD-standard deviation; t-test value; p-value significant at >0.005.

Results of t-test statistics showed that there is a visible significant fall between shooting velocity and swimming, and therefore demonstrate that this polygon is leading to fatigue and gives the result of efficiency. Such examples could be found in other sports, such as basketball (Callaway and Broomfield, 2012). This study showed that at the end of sport-specific polygon, there is a decrease of shooting precision, which can be connected to our findings. Furthermore, lower shooting velocity and slower swimming can be connected to the real match situation, where players need to endure defense and then swim to the offense with the possible shoot.

Table 2 shows th

e correlation matrix between measured variables in rest and in the polygon.

Table 2. *Correlations between measured variables in rest and in polygon.*

Variable	***Average force 20 sec***	***20min polygon***	***Shoot in polygon***	***Sum of all % in polygon***
Average force in polygon	*0.08*	*-0.49*	*0.76**	*0.43*
Shoot	*0.16*	*-0.68**	*0.92**	*0.60*
20m	*-0.46*	*0.64**	*-0.80**	*-0.77**

Analysis of correlation shows that there is a significant positive correlation between swimming and shooting velocity at rest with the same variables in the polygon. Additionally, an important finding is that there is a positive relation between dynamometer force at rest and shooting velocity after the polygon, which is an important indicator because the shoot is at the end of the polygon. Such results could imply that those who can produce more force in defense can go into attack with more rest. Moreover, shooting velocity is important as was previously shown (Alcaraz et al., 2011; Alcaraz et al., 2012; Smith, 1998).

Furthermore, there is a significant negative correlation between shooting velocity at rest and swimming in the polygon. Such a result is logical, mainly because the shot does not depend on the swimming speed. Also, other team sports, such as football, showed that running velocity and shooting velocity are negatively connected (Russell et al., 2011).

CONCLUSION

Sport-specific tests such as the one in our study showed good reliability and validity in defining the status of motoric abilities in young water polo players. In this study, participants are playing in one of the best water polo leagues in Europe, and such tests and results could be used to define training regimes.

Future studies should focus on other age groups, and possible female players to define the applicability of water polo as a whole. Limitations of this study are the small sample of participants and the fact that players are only

from one team. Also, it could be valuable to define possible gender differences.

REFERENCES

1. Uljevic, O., Spasic, M., & Sekulic, D. (2013). Sport-specific motor fitness tests in water polo: reliability, validity and playing position differences. *Journal of sports science & medicine*, *12*(4), 646.

2. Russell M., Benton D., Kingsley M.(2010). Reliability and construct validity of soccer skills tests that measure passing, shooting, and dribbling. *Journal of Sports Sciences* 28(13), 1399-1408 [PubMed] [Google Scholar]
3. Russell M., Benton D., Kingsley M.(2011). The Effects of Fatigue on Soccer Skills Performed During a Soccer Match Simulation. *International Journal of Sports Physiology and Performance* 6(2), 221-233 [PubMed] [Google Scholar]
4. Sajber D., Peric M., Spasic M., Zenic N., Sekulic D.(2013). Sport-specific and anthropometric predictors of synchronised swimming performance. *International Journal of Performance Analysis in Sport* 13(1), 23-37 [Google Scholar]
5. Lozovina V., Pavicic L., Lozovina M.(2003). Analysis of indicators of load during the game in activity of the second line attacker in water polo. *Collegium Antropologicum* 27(1), 343-350 [PubMed] [Google Scholar]
6. Alcaraz P.E., Abraldes J.A., Ferragut C., Rodriguez N., Argudo F.M., Vila H.(2011). Throwing velocities, anthropometric characteristics, and efficacy indices of women's European water polo subchampions. *Journal of Strength &Conditioning Research* 25(11), 3051-3058 [PubMed] [Google Scholar]
7. Alcaraz P.E., Abraldes J.A., Ferragut C., Vila H., Rodriguez N., Argudo F. M.(2012). Relationship between characteristics of water polo players and efficacy indices. *Journal of Strength & Conditioning Research* 26(7), 1852-1857 [PubMed] [Google Scholar]
8. Callaway A.J., Broomfield S.A.(2012). Inter-Rater Reliability and Criterion Validity of Scatter Diagrams as an Input Method for Marksmanship Analysis: Computerised Notational Analysis for Archery. *International Journal of Performance Analysis in Sport* 12(2), 291-310 [Google Scholar]
9. Kondric M., Uljevic O., Gabrilo G., Kontic D., Sekulic D.(2012). General anthropometric and specific physical fitness profile of high-level junior water polo players. *Journal of Human Kinetics* 32, 157-165

10. Meckel Y., Machnai O., Eliakim A.(2009). Relationship among repeated sprint tests, aerobic fitness, and anaerobic fitness in elite adolescent soccer players. *Journal of Strength and Conditioning Research* 23(1), 163-169 [PubMed] [Google Scholar]
11. Melchiorri G., Castagna C., Sorge R., Bonifazi M.(2010). Game activity and blood lactate in men's elite water-polo players. *Journal of Strength and Conditioning Research* 24(10), 2647-2651 [PubMed] [Google Scholar]
12. Melchiorri G., Manzi V., Padua E., Sardella F., Bonifazi M.(2009). Shuttle Swim Test for water polo players: validity and reliability. *Journal of Sports Medicine and Physical Fitness* 49(3), 327-330
13. Tan F.H.Y., Polglaze T., Dawson B.(2009a). Comparison of progressive maximal swimming tests in elite female water polo players. *International Journal of Sports Physiology and Performance* 4(2), 206-217 [PubMed] [Google Scholar]
14. Tan F.H.Y., Polglaze T., Dawson B.(2010). Reliability of an In-Water Repeated-Sprint Test for water polo. *International Journal of Sports Physiology and Performance* 5(1), 117-120 [PubMed] [Google Scholar]
15. Tan F.H.Y., Polglaze T., Dawson B., Cox G.(2009b). Anthropometric and fitness characteristics of elite Australian female water polo players. *Journal of Strength and Conditioning Research* 23(5), 1530-1536 [PubMed] [Google Scholar]
16. Gobbi M., D'Ercole C., D'Ercole A., Gobbi F.(2011). The components of jumps in expert and intermediate water polo players. *Journal of Strength & Conditioning Research.* (In press). [PubMed] [Google Scholar]
17. Smith H. K.(1998). Applied physiology of water polo. *Sports Medicine* 26(5), 317-334 [PubMed] [Google Scholar]

Experts' Opinions on the Changes to the Water Polo Rules: Analysis in Latent Space

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ABSTRACT

The goal of this research is to determine and explain the latent structure of water polo experts' opinions about changes in the rules of the water polo game. The sample of respondents is represented by 50 water polo experts from Croatia. The sample of variables contains a questionnaire of 20 closed-ended questions on Likert type scale graded 1 to 5. Exploratory strategy of factor analysis with varimax raw rotation revealed the existence of eight latent dimensions which explains 79% of variability in total. Water polo experts gave the greatest importance to the changes to the water polo rules that would affect the greater dynamics of the game in the form of better flow of the game, better defined spatial and temporal parameters and more tactical combinations in the attack. Experts estimate that the amended penalty rule would give the players and the goalkeeper new performance options, which would certainly make the game more attractive. In the further hierarchical structure of the improvement of the water polo game, experts state the determinant in the form of safety and signaling of the game. The reduction in the number of violations and the possibility of delaying major fouls as a latent dimension in the form of favoring attackers in water polo are the last two factors that experts give importance in the overall evolution of the water polo game.

Keywords: factor analysis, questionnaire, dynamics of the game, attractiveness of the game

INTRODUCTION

Water polo rules are a written document that confirms, organizes and conducts a water polo match. Research according to Donev and Aleksandrović (2008) showed that modern water polo has little resemblance to the original game that appeared in England. Through the historical development of the water polo game, five developmental stages have been determined and one future, hypothetical stage is predicted (Hraste, Bebić & Rudić, 2013). Changes to the rules of the game have not always produced positive effects. The basic intention of changing the water polo rules is to make water polo as attractive and interesting to spectators (Lozovina & Lozovina, 2009). The 2019 water polo rules make certain changes to the 2013 rules. Water polo, which was played until 2019, belongs to the last historical stage, which is characterized by a game of high rhythm and tempo, however, at the same time, static water polo prevails in the positional phases of the game with a lot of major fouls, contacts and duel games "on the border of the incident", with little penetration and a bit of tactical combinatory in the attack phase (Hraste, 2021). The consequence of the new rules should be a reduction in rough play,

speeding up the game, which will enable a greater degree of expression of technical-tactical knowledge and skills during the game. Expert opinion is an analysis of a given consideration of a phenomenon. In water polo research, Hraste, Dizdar and Trninić (2008; 2010) analyzed expert opinions on the assessment of the real quality of top water polo players based on the proposed comprehensive criteria and empirically verified their expert assessment. In sports, including water polo, it is very important to examine different opinions on a given issue and to determine the degree of (dis)agreement through analysis. Water polo experts are the most invited and the most meritorious to determine the degree of significance of a certain change that would contribute to the improvement and attractiveness of the water polo game. Previous research that determined and explained latent dimensions in water polo was related to the factor analysis of specific motor tests (Uljević, Spasić, & Sekulić, 2013) and the determination of the factor structure of performance in the game (Takagi, Nishijima, Enomoto, & Stewart, 2005).

The aim of this research is to determine and explain the opinions of water polo experts about changes in the rules of the water polo game and to determine their evaluation based on factor analysis.

METHODS

The sample of respondents is 50 water polo experts from Croatia. The sample of variables contains a questionnaire of 20 closed questions with five possible answers. Each of the 20 questions referred to an expert assessment of how much a changed water polo rule would affect the structure of the game. This research was conducted in 2018. So, a year before the changes to the water polo rules were adopted. The five possible answers out of 20 closed-ended questions were: a) it would not affect; b) it would have little effect; c) would have a moderate effect; d) would significantly affect; e) would have a very significant effect. The questionnaire of 20 closed questions was: (1) reduction of attack time for the second attack after a corner or exclusion (**RAT**); (2) the foul should be taken from where the ball is, not where the foul was committed (**FOUL**); (3) from a corner or out, you can shoot directly at the goal or you can swim and shoot without passing the ball to a teammate (**CORN**); (4) awarding an exclusion or a penalty can be delayed, that is, an advantage can be given to the attacker (**ADVA**); (5) limit the period for the center forward as long as he can be in front of the goal, in the space within six meters and between the two posts (**LIMIT**); (6) the substitution area would be located halfway up the field for a more dynamic game (**SAREA**); (7) the shooting line after an ordinary foul moves from five to six meters, and a goal can be scored except by a direct shot at the goal, and after feinting, dribbling or putting the ball on the water (**LIN6M**); (8) introduction of a clear signal from the referee entitling the player to shoot directly from the six meter line for situations where it is unclear whether the attacker is inside or outside the free throw line (**CLESG**); (9) the goalkeeper is allowed to move and touch the ball across half of the field, and at the end of the game the goalkeeper can go to the attacking half of the field and score a goal (**GOALK**); (10) the attacking team must transfer the ball to the attacking half of the field in 10-15 seconds and after that they have no right to return it to the defensive half of the field (**BALLA**); (11) each team has the right to two timeouts, each of which lasts 1 minute, and they

can be requested in the same quarter (**2TO**); (12) a penalty can be taken from anywhere on the six-meter line. It is allowed to move laterally, feint and place the ball on the surface. The goalkeeper is allowed to go out to the two-meter line (**PEN6M**); (13) modifying rule 20.1. related to ordinary fouls. The rule would be rewritten to reduce the number of "light" fouls, referee whistles, stoppages, holding, grabbing and pulling. A personal (serious) offense will be for committing any of the following offenses (WP 20.2 to WP 20.5) except WP 20.2, 20.6, 20.7, 20.10, 20.12, 20.14, 20.15 and 20.16. (**MOORF**); (14) introduce a personal foul, which will be awarded when the center defender "fouls" the center forward without the ball instead of exclusion (**CEDEF**); (15) button that will be used to call timeout (**BUTTO**); (16) a system for recording matches, with which referees will more easily notice illegal brutality in the game and be able to punish the player after the match is over (**SYREM**); (17) use of audio communication devices for referees during the match (**AUDIO**); (18) reduce the halftime break from 5 to 3 minutes (**REDHT**); (19) each team will consist of 13 players + 2 substitutes in competitions such as the World League and the World Cup, and the list of players can be changed at each match (**15PLY**); (20) by using visual effects around the suspended player, the official desk informs us of the last five seconds of the suspension and the end of the suspension (**VISEF**).

In this research, descriptive statistical parameters have been calculated: arithmetic mean±standard deviation (M±SD), median (MED), minimum (MIN) and maximum score (MAX) together with skewness (SKE) and kurtosis (KURT). Furthermore, Kolmogorov Smirnov test was used for normality testing. Exploratory strategy of factor analysis with varimax raw rotation and Guttman Kaiser criterion was used to identify existence of latent dimensions. All calculations were performed on statistical analysis software system Statistica 14.0. (TIBCO Software Inc. (2020). Data Science Workbench). Type I error was set at α=5%.

RESULTS and DISCUSION

As Kolmogorov Smirnov test indicated that only 4 variables had distribution with mild deviation from normality, parametric statistical methods are used.

Table 1 shows the central and dispersive parameters based on expert opinions on the importance of changes to the rules of the water polo game. Arithmetic means, medians, minimum scores, maximum scores, standard deviations, skewness and kurtosis were calculated.

Table 1: *Descriptive indicators of the variables of the proposed changes to the rules of the water polo game. M±SD-arithmetic mean± standard deviation, MED-median, MIN-minimum score, MAX-maximum score, SKE-skewness, KUR-kurtosis*

Varijable	*M±SD*	*MED*	*MIN*	*MAX*	*SKE*	*KUR*
RAT	*3,24±0,87*	*3,00*	*1,00*	*4,00*	*-1,08*	*0,63*
FOUL	*3,60±0,95*	*4,00*	*1,00*	*5,00*	*-0,60*	*0,07*
CORN	*3,08±1,14*	*3,00*	*1,00*	*5,00*	*-0,33*	*-0,61*
ADVA	*3,60±0,97*	*4,00*	*1,00*	*5,00*	*-0,65*	*-0,04*
LIMIT	*3,32±1,38*	*4,00*	*1,00*	*5,00*	*-0,51*	*-0,88*

SAREA	*3,74±0,99*	*4,00*	*1,00*	*5,00*	*-0,38*	*-0,22*
LIN6M	*3,50±1,05*	*4,00*	*1,00*	*5,00*	*-0,71*	*0,17*
CLESG	*3,04±1,09*	*3,00*	*1,00*	*5,00*	*-0,08*	*-0,65*
GOALK	*3,70±1,05*	*4,00*	*1,00*	*5,00*	*-0,88*	*0,29*
BALLA	*2,86±1,09*	*3,00*	*1,00*	*5,00*	*0,09*	*-0,70*
2TO	*2,32±1,00*	*2,00*	*1,00*	*5,00*	*0,33*	*-0,33*
PEN6M	*3,00±1,44*	*3,00*	*1,00*	*5,00*	*-0,00*	*-1,37*
MOORF	*3,34±0,94*	*3,00*	*1,00*	*5,00*	*-0,44*	*0,17*
CEDEF	*3,10±1,05*	*3,00*	*1,00*	*5,00*	*-0,32*	*-0,53*
BUTTO	*2,26±1,23*	*2,00*	*1,00*	*5,00*	*0,79*	*-0,13*
SYREM	*3,46±1,33*	*4,00*	*1,00*	*5,00*	*-0,32*	*-1,13*
AUDIO	*2,98±1,36*	*3,00*	*1,00*	*5,00*	*-0,01*	*-1,22*
REDHT	*2,46±1,39*	*2,00*	*1,00*	*5,00*	*0,54*	*-0,94*
15PLY	*3,28±1,25*	*3,00*	*1,00*	*5,00*	*-0,30*	*-0,88*
VISEF	*2,86±1,14*	*3,00*	*1,00*	*5,00*	*-0,06*	*-0,82*

***Legend**: **RAT**-reduction of attack time for the second attack after a corner or exclusion; **FOUL**-the foul should be taken from where the ball is; **CORN**-from a corner or out, you can shoot directly at the goal or you can swim and shoot without passing the ball to a teammate; **ADVA** -awarding an exclusion or a penalty can be delayed; **LIMIT** - limit the period for the center forward as long as he can be in front of the goal, in the space within six meters and between the two posts; **SAREA**-the substitution area would be located halfway up the field for a more dynamic game; **LIN6M**-the shooting line after an ordinary foul moves from five to six meters, and a goal can be scored except by a direct shot at the goal, and after feinting, dribbling or putting the ball on the water; **CLESG**-introduction of a clear signal from the referee; **GOALK** -the goalkeeper is allowed to move and touch the ball across half of the field; **BALLA**-the attacking team must transfer the ball to the attacking half of the field in 10-15 seconds; (11) **2TO**-each team has the right to two timeouts; **PEN6M**-a penalty can be taken from anywhere on the six-meter line, is allowed to move laterally, feint and place the ball on the surface and the goalkeeper is allowed to go out to the two-meter line; **MOORF**-modifying rule related to ordinary fouls; **CEDEF**-introduce a personal foul for the center defender; **BUTTO**-button that will be used to call timeout; **SYREM**-a system for recording matches; **AUDIO**-use of audio communication devices for referees; **REDHT**-reduce the halftime break from 5 to 3 minutes; **15PLY**-each team will consist of 13 players + 2 substitutes; **VISEF**-using visual effects around the suspended player*

From Table 1, it can be seen that the arithmetic means of the variables vary from 2.26 to 3.74. According to the results of the dispersive indicators, the approximate normality of the distribution can be observed.

***Table 2:** Factor analysis of the opinions of water polo experts on changes to the rules of the water polo game (Expl.Var – variability explained by single factor; Prop.Totl – proportion of variability explained by single factor)*

Variable	*Factor 1*	*Factor 2*	*Factor 3*	*Factor 4*	*Factor 5*	*Factor 6*	*Factor 7*	*Factor 8*
RAT	*-0,45*	*0,19*	*0,71*	*0,04*	*0,22*	*-0,14*	*0,30*	*-0,04*
FOUL	*-0,87*	*-0,16*	*0,19*	*0,00*	*0,04*	*-0,04*	*0,00*	*0,13*
CORN	*-0,02*	*-0,21*	*0,81*	*0,12*	*-0,17*	*0,14*	*-0,08*	*0,17*
ADVA	*-0,09*	*0,04*	*0,10*	*0,04*	*0,10*	*0,04*	*-0,10*	*0,91*
LIMIT	*0,09*	*0,53*	*0,51*	*0,19*	*-0,24*	*-0,14*	*0,04*	*0,37*

SAREA	*0,49*	*0,62*	*0,20*	*0,30*	*0,08*	*-0,20*	*0,01*	*0,06*
LIN6M	*0,05*	*0,85*	*-0,14*	*-0,14*	*0,09*	*0,10*	*-0,04*	*0,01*
CLESG	*0,11*	*0,45*	*0,23*	*-0,32*	*0,32*	*0,53*	*0,07*	*0,10*
GOALK	*-0,16*	*0,17*	*-0,05*	*0,09*	*0,75*	*0,10*	*-0,25*	*0,08*
BALLA	*0,10*	*0,03*	*0,72*	*-0,12*	*0,29*	*0,22*	*-0,03*	*-0,05*
2TO	*-0,02*	*0,03*	*0,06*	*0,12*	*-0,02*	*0,94*	*0,03*	*0,00*
PEN6M	*-0,12*	*0,17*	*-0,14*	*0,80*	*-0,06*	*0,01*	*0,27*	*0,23*
MOORF	*0,04*	*0,12*	*0,03*	*0,05*	*0,01*	*0,10*	*0,86*	*-0,08*
CEDEF	*-0,10*	*0,74*	*0,00*	*0,19*	*-0,12*	*0,04*	*0,45*	*-0,08*
BUTTO	*0,02*	*-0,35*	*-0,04*	*-0,19*	*0,09*	*0,52*	*0,22*	*0,46*
SYREM	*0,34*	*0,01*	*0,26*	*-0,18*	*0,59*	*-0,01*	*0,37*	*-0,01*
AUDIO	*0,57*	*-0,39*	*0,22*	*0,17*	*0,36*	*-0,08*	*0,32*	*0,05*
REDHT	*0,21*	*-0,08*	*0,24*	*0,77*	*0,28*	*0,09*	*-0,17*	*-0,15*
15PLY	*-0,08*	*-0,11*	*-0,07*	*0,04*	*0,77*	*-0,01*	*0,12*	*0,23*
VISEF	*0,31*	*-0,04*	*0,20*	*0,44*	*0,66*	*0,00*	*0,00*	*-0,15*
Expl.Var	*1,87*	*2,61*	*2,33*	*1,88*	*2,53*	*1,65*	*1,53*	*1,42*
Prp.Totl	*0,09*	*0,13*	*0,12*	*0,09*	*0,13*	*0,08*	*0,08*	*0,07*

***Legend**: **RAT**-reduction of attack time for the second attack after a corner or exclusion; **FOUL**-the foul should be taken from where the ball is; **CORN**-from a corner or out, you can shoot directly at the goal or you can swim and shoot without passing the ball to a teammate; **ADVA** -awarding an exclusion or a penalty can be delayed; **LIMIT** - limit the period for the center forward as long as he can be in front of the goal, in the space within six meters and between the two posts; **SAREA**-the substitution area would be located halfway up the field for a more dynamic game; **LIN6M**-the shooting line after an ordinary foul moves from five to six meters, and a goal can be scored except by a direct shot at the goal, and after feinting, dribbling or putting the ball on the water; **CLESG**-introduction of a clear signal from the referee; **GOALK** -the goalkeeper is allowed to move and touch the ball across half of the field; **BALLA**-the attacking team must transfer the ball to the attacking half of the field in 10-15 seconds; (11) **2TO**-each team has the right to two timeouts; **PEN6M**-a penalty can be taken from anywhere on the six-meter line, is allowed to move laterally, feint and place the ball on the surface and the goalkeeper is allowed to go out to the two-meter line; **MOORF**-modifying rule related to ordinary fouls; **CEDEF**-introduce a personal foul for the center defender; **BUTTO**-button that will be used to call timeout; **SYREM**-a system for recording matches; **AUDIO**-use of audio communication devices for referees; **REDHT**-reduce the halftime break from 5 to 3 minutes; **15PLY**-each team will consist of 13 players + 2 substitutes; **VISEF**-using visual effects around the suspended player*

From Table 2, it can be seen that the factor analysis established the existence of eight latent dimensions about the opinions of water polo experts about changes in the rules of the water polo game. The first latent dimension: *Game dynamism as a consequence of better game flow*. The first factor is determined by the variables: reducing the attack time for the second attack after a corner or exclusion; the foul should be taken from where the ball is; the place for changing players would be located halfway up the field; the use of audio communication devices for the referees during the match. This latent dimension is defined above all by variables that would significantly influence the greater flow of the game. Reducing the time of attacks after corners or exclusion, rule about fouls and allowing

substitutions to be made in the entire longitudinal half of the field would very likely contribute to more attacks during matches and generally "speeding up" the game. Better communication between the referees and the official desk will most likely prevent the game from stopping in contested situations to a greater extent and also contribute to a better flow of the game. The second latent dimension: *The dynamism of the game as a result of better defined spatial-temporal determinants*. The second latent dimension is determined to the greatest extent by the projections of the variables related to the limitation of the period for the center forward, how long he may be in front of the goal, in the space within six meters and between the two goalposts; for the shooting line on six meters; for the place for replacing players that would be halfway up the field; the introduction of a clear signal from the referee which entitles a player to shoot directly from the six-yard line for situations where it is unclear whether the attacker is inside or outside the free-throw line. Limiting the period of the center forward stays on a part of the playing field would certainly reduce the static and improve the dynamism of the game. An exemplary example is basketball, where holding the racket for more than three seconds is sanctioned. An additional contribution to the dynamism of the game would be made by "flying" changes to the defensive half of the field, more attacking possibilities after a foul outside six meters and the referee's signaling of the spatial determination of the offense. The third latent dimension: *The dynamism of the game as a result of multiple tactical combinations in the attack*. The third latent dimension is primarily determined by the positive projections of the variables: reducing the time of the attack for the second attack after a corner or an exclusion; from a corner or an out you can directly shoot at the goal or you can swim and shoot without passing the ball to a teammate; limit the period for the center forward to be in front goal, in the space within six meters and between the two posts; a penalty and free throw can be taken from anywhere on the six meter line. The new rules for taking corners, free throw and penalty, as well as preventing the center from playing static games, give a greater possibility of tactical combinatory in the attack. Preparing a "second" attack after a corner and a throw-in in time-reduced conditions will force coaches and players to look for a faster and more innovative game in the attack phase. The fourth latent dimension: *Attractiveness of the game*. The fourth latent dimension is determined by the projections of the variables: a penalty can be taken from anywhere on the six-meter line, it is allowed to move laterally, feint and place the ball on the surface, and the goalkeeper is allowed to go out to the two-meter line; reduce the halftime break from five to three minutes. The new penalty rule gives the players and the goalkeeper new opportunities for performance, which would certainly make the game more attractive. Reducing the time-out time from five minutes to three minutes reduces the inactive time of the game. The fifth latent dimension: *Safety and attractiveness of the game*. The fifth factor is determined by variables: the goalkeeper is allowed to move and touch the ball across half of the field; a system for recording matches; each team will consist of 13 players + 2 substitutes; using visual effects around the suspended player; official desk informs for the last 5 seconds of the suspension. The use of video technology to detect possible brutality in the game and the possibility of changing up to two players in each match

certainly contributes to the safety of the players in the case of the prevention of brutality and the aggravation of injuries. The possibility of playing goalkeeper in the attack and the use of visual effects gives an additional contribution to the uncertainty and attractiveness of the game. The sixth latent dimension: *Game signaling*. The sixth latent dimension is primarily determined by the positive projections of variables: the introduction of a clear signal from the referee entitling the player to shoot directly from the six-meter line for situations in which it is unclear whether the attacker is inside or outside the free throw line and the button will serve to call a timeout. The introduction of better signaling of the game through gestures and pressing the button gives a significant contribution to the game in the form of canceling ambiguities. The seventh latent dimension: *Favoring the attacker in the game in the form of reducing the number of fouls*. The seventh latent dimension is determined to the greatest extent by the projections of the variables: modifying rule 20.1. related to ordinary fouls; introduce a personal foul of center defender in contact with center forward without a ball. The "new" penalization of the game after ordinary and major fouls will make a significant contribution to favoring attackers in water polo. Namely, the excessive number of common fouls in water polo favors defensive activity at the expense of the attacking phase, which, according to a large number of water polo experts, "suffocates" the game. The eighth latent dimension: *Favoring the attacker in the game. in the form of the possibility of delaying the exclusion and penalty*. The eighth latent dimension is dominantly determined by a variable: awarding an exclusion or a penalty can be delayed, that is, an advantage can be given to the attacker. Another favoring of attacking activity undoubtedly contributes to the better flow of the water polo game.

CONCLUSION

Water polo experts gave the greatest importance to the changes to the water polo rules that would affect the greater dynamics of the game in the form of better flow of the game, better defined spatial and temporal parameters and more tactical combinations in the attack. Experts estimate that the amended penalty kick rule would give the players and the goalkeeper new performance options, which would certainly make the game more attractive. In the further hierarchical structure of the improvement of the water polo game, experts state the determinant in the form of safety and signaling of the game. The reduction in the number of violations and the possibility of delaying the award of major fouls as a latent dimension in the form of favoring attackers in water polo are the last two factors that experts give importance in the overall evolution of the water polo game.

REFERENCES

1. Donev, Y., Aleksandrović, M. (2008). History of rule changes in water-polo. *Sport Science, 1(2),* 16-22.

2. Hraste, M., Dizdar, D., & Trninić, V. (2008). Experts Opinion about System of the Performance Evaluation Criteria Weighted per Positions in the Water Polo Game. *Collegium Antropologicum, 32*(3), 851-862.
3. Hraste M., Dizdar, D., & Trninić, V. (2010) Empirical Verification of the Weighted System of Criteria for the Elite Water Polo Players Quality Evaluation. *Collegium Antropologicum, 34*(2), 473-479.
4. Hraste, M., Bebić, M., & Rudić, R. (2013). Where is today's Water Polo Heading? An Analysis of the Stages of Development of the Game of Water Polo. *Naše more, 60*(1-2), Supplement, pp. 17-22.
5. Hraste, M. (2021). *Water polo/Vaterpolo*. Faculty of Kinesiology. University of Split.
6. Lozovina, M. and Lozovina, V. (2009). Attractiveness lost in the water polo rules. *Sport Science 2*(2), 85-89.
7. Uljevic, O., Spasic, M., & Sekulic, D. (2013). Sport-specific motor fitness tests in water polo: reliability, validity and playing position differences. *Journal of sports science & medicine*, *12*(4), 646.
8. Takagi, H., Nishijima, T., Enomoto, I., & Stewart, A. M. (2005). Determining factors of game performance in the 2001 world Water Polo Championships. *Journal of human movement studies*, *49*(2), 333-352.

Playing Position Differences in The Parameters of Anthropometry and Sport-Specific Motor Tests in Young Water Polo Players

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ABSTRACT

The shot in water polo is a skill in which it is necessary to throw the ball as hard as possible towards the goal to score a goal. Ability to coordinate quick and precise shots of the ball towards the goal is one of the most important factors affecting the result and an important indicator of success for water polo players. The aim of this paper was to explain the playing position differences in anthropometry and sport specific motor tests in young water polo players. The sample in this research consists of 24 young water polo players aged 15 to 18 (M = 16.71 years) who play different roles in three positions in water polo, defenders (11), centers (9) and goalkeepers (4). Morphological variables were measured with standard anthropometric equipment, and they are: standing height, arm span, body weight, subcutaneous fat tissue. Sport-specific variables are: drive shot, fake shot, pass shot. Univariate analysis of variance revealed that four variables differed statistically significant between player positions. These are body weight, drive shot, fake shot and pass shot. This result can be applied in the future in order to improve performance of the future generations involved in water polo, and to raise the level of quality in the sport and therefore progress in the future.

INTRODUCTION

The history of water polo as a team sport began as a demonstration of strength and swimming skills at the end of the 19th century in the United Kingdom, on the rivers and lakes of England and Scotland. Besides soccer, water polo is the oldest team sport that appeared in the Olympic Games since 1900 and has continued until today. The first winner was Great Britain. Water polo for women was included for the first time at the Olympic Games in Sydney in 2000.
A water polo match is played in four quarters of eight minutes each. There is a two-minute break between the first and second quarter and the third and fourth quarter. The break between the second and third quarters lasts five minutes, which is also half time. The teams can use up to 3 coaching breaks (time outs) lasting one minute each. One team may keep the ball in possession during the attack for a maximum of 30 seconds. A goal is scored when the ball crosses the imaginary line between the goalposts and under the crossbar.
Each team must have seven players, who are required to play different roles on the field. Goalkeeper: the player who is responsible for standing in front of the goal, i.e., between the goal posts. Goalkeeper is the only player permitted to touch the ball with two hands. Wings: The most widely positioned players on the field who are on the two-meter line in attack and defense. Drivers: the players who are closer to the center compared to the wing players who are positioned on the 5–6-meter line are called

left and right drivers I.e flats. Center: the player who is in the attack between the outside players at 6-7 meters is called the center forward. The position of the center forward in defense has the biggest role and he is positioned on the line of two meters in front of the goalkeeper. Point: the center in attack is positioned in the middle of the line two meters in front of the opponent's goalkeeper, while in defense he is positioned farthest from his goal.

One of the most important segments in a water polo match is the shot towards the goal, because it determines the success of each team's attack. The shot in water polo is a skill in which it is necessary to throw the ball as hard as possible towards the goal to score a goal. The faster the shot, the greater the chances of scoring a goal, because the defenders and the goalkeeper have less time to react to the ball. Therefore, the ability to coordinate quick and precise shots of the ball towards the goal is one of the most important factors affecting the result and an important indicator of success for water polo players. (Stirn i Strojnik, 2006). Elite male players achieve peak ball velocities higher than 20 m/sec. (Feltner i Taylor, 1997; Darras, 1999).

The aim of this paper was to explain the playing position differences in anthropometry and sport specific motor tests in young water polo players.

METHODS

Participants

The sample in this research consists of 24 young water polo players aged 15 to 18 (M = 16.71 years) who play different roles in three positions in water polo, defenders (11), centers (9) and goalkeepers (4). All participants have been playing water polo for more than four years and train four to six times a week.

Variables

The variables used in this research can be divided into two main groups, namely variables for the assessment of morphological features and variables of specific skills (sport-specific tests).

Morphological variables were measured with standard anthropometric equipment, and they are: standing height, arm span, body weight, subcutaneous fat tissue. Sport-specific variables are: drive shot, fake shot, pass shot. In order to obtain the results as accurately as possible, the break between test attempts lasted two to three minutes, and the break between tests lasted five to eight minutes.

Testing procedures

The testing was carried out in the period from October to December 2022. The participants were players from the "Invictum" Sarajevo Water Polo Club. Before testing, consent to conduct the research was requested from the club management, then the coaches, as well as the parents of the players who were tested.

The procedure took place immediately before each training session at the Olympic pool “Otoka” Sarajevo. The participants were devided in groups of five to six players, so that the testing could be carried out as precisely as possible. It started with morphological measurements, standard anthropometric equipment, electronic scale, caliper and meter, early in the morning before training. Standing height was measured (measured with a meter from head to toe while a player is standing upright against a wall), arm span (measured with a tape measure from the middle finger on the left hand to the middle finger on the right hand while a player is standing against the wall with arms spread out at shoulder height), body

weight (measured in the early morning hours, before the first meal, with an electronic scale), subcutaneous fat tissue (measured with a caliper on the region of the body between the abdomen and the groin).

Before continuing the procedure in the pool, the players were explained what specific tests they will perform and what their tasks are. After they listened to explanation, they went through the preparation before testing in the pool. Participants had enough time to prepare and warm up for the test. Each player had the task of hitting the target in the pool at a distance of six meters, which, in this case, was the goalkeeper at the goal. Behind the goal was a coach with a radar gun (Bushnell Velocity Speed Gun) that reads the speed of the ball's flight, which measures the speed of the shot. The testing was done with a Malmsten water polo ball (WP5 Men), which is used for training and competitions. Ball weight 400-450 grams. For men's water polo, the ball's circumference must be 0.68 - 0.71 m, and its pressure must be 55 - 62 kPa. Each participant had 3 repetitions to shoot on goal. The first task was the drive shot, where the player was in the basic water polo position holding the ball, six meters away from the measurer. The task is to rise out of the water and hit the target i.e goalkeeper. In the second task fake shot, player is in the basic water polo position holding the ball and he is 6 meters away from the measurer. In the middle of the goal there is a goalkeeper who represents the goal. The player's task is to rise out of the water to "swing" optimally and from the third swing hit the ball most powerfully at the target, i.e. the goalkeeper. In the third task pass shot, the player is in the basic water polo position to receive the ball six meters away from the measurer. The player's task is to rise out of the water and receive the optimal ball with the help of an assistant and, without interruption of movement, hit the ball most powerfully at the target, i.e. the goalkeeper.

RESULTS

Table 1. shows the values of the mean, minimum and maximum value, standard deviation, as well as measures of asymmetry of the distribution (skewness) and measures of the elongation of the distribution (kurtosis) related to the age of the players, the position they play, body weight and height, arm span, abdomen skinfold, shot from water, swing shot and passing shot.

Table 1. Descriptive statistics measurements

	N	Mean	MIN	MAX	SD	Skew.	Kurt.
Age	24	16,71	15,00	18,00	0,91	0,26	-1,10
Position	24	2,29	1,00	3,00	0,75	-0,55	-0,95
Height (cm)	24	185,08	174,00	194,00	4,83	-0,42	0,38
Weight (kg)	24	80,08	70,00	95,00	6,30	0,60	0,33
Arm span (cm)	24	188,95	179,00	198,00	5,14	-0,33	-0,32
Abdomen skinfold	24	10,87	6,00	20,00	3,91	0,77	0,07
Drive shot	24	59,42	50,00	69,00	4,22	0,31	0,67
Fake shot	24	57,67	50,00	67,00	4,10	0,21	0,14

Pass shot	24	57,37	50,00	64,00	4,04	-0,41	-0,76

Based on the results obtained, it is evident that the values of skewness and kurtosis are within the range of values that imply a normal distribution.

Multivariate analysis revealed that the groups (goalkeepers, centers, drivers) differ statistically significant in morphological variables (F=2.98; p=0.01) and shooting variables (F=2.40; p=0.04).

Univariate analysis of variance revealed that four variables differed statistically significant between player positions. These are body weight, drive shot, fake shot and pass shot. Scheffe's post hoc test shows that in the body weight variable, there is a statistically significant difference between goalkeepers and centers at the 0.05 significance level. It is also evident that in the drive shot variable, the first and third group (goalkeepers and drivers), differ significantly. In the fake shot variable, the first and second and first and third groups differ significantly, i.e. goalkeepers and drivers and goalkeepers and centers. In the pass shot variable, the first and second and first and third groups, i.e. goalkeepers and drivers and goalkeepers and centers, are significantly different.

Table 2. Univariate analysis of group differences according to positions, body weight, body height, arm span, skin fold, drive shot, fake shot and pass shot

	Goal keeper	Center	Driver	F	P
	Mean/SD	Mean/SD	Mean/SD		
Height	187,50/2,41	183,55/1,61	185,45/1,45	0,98	0,39
Weight	74/2,82	83,33/1,88	79,63/1,67	3,85	0,04*
Arm span	190,50/2,51	186,66/1,67	190,27/1,51	1,50	0,25
Abd. skinfold	8,50/1,84	12,88/1,23	10,09/1,11	2,41	0,11
Drive shot	54,50/1,85	59,88/1,23	60,81/1,11	4,36	0,03*
Fake shot	52,25/1,71	58,55/1,14	58,90/1,03	6,04	0,008*
Pass shot	51,75/1,63	58,66/1,08	58,36/0,98	7,16	0,004*

LEGEND: Mean, standard deviation, F - value used to determine the statistical significance of the differences between arithmetic means of groups, P - represents the error.

DISCUSSION

The analysis of morphological characteristics in this paper showed that goalkeepers are taller than centers and drivers, as well as that centers are heavier than goalkeepers and drivers. The arm span is the largest in goalkeepers and drivers, while centers have the highest percentage of fat tissue. Further, the differences between player positions in morphological variables were examined, and it was determined that goalkeepers are the highest, followed by drivers and then centers. If we compare this research with the research of Uljević et al. (2013), we will notice that in that

research the highest are centers, followed by drivers and then goalkeepers. The difference in that research is based on a larger number of respondents, it was also stated that Croatian water polo favors, hence selects higher players, and one of the differences may be in the genetics, as well as the development of the sport itself in Croatia and Bosnia and Herzegovina.

When it comes to body weight, the difference is obvious due to the morphological predispositions of each position in water polo, according to which the full capacity of the water polo player and his role can be achieved. Due to the constant body contact during the game, the center should be taller and heavier than the other players. In this paper, the centers are the heaviest and have an increased level of fat tissue. In the research of Uljević et al. (2013), goalkeepers, although not statistically significant, are dominant in arm span and have lower BMI values, which coincides with this study, where goalkeepers are also dominant in arm span and have the lowest levels of fat tissue. The reason for this is that goalkeepers are the pillars of the defense and have no physical contact. On the other hand, the center is the backbone of the attack in water polo, based on which the entire game is formed, and every coach strives for the center to have exceptional physical strength due to its role in the attack. Speaking of specific motor skills, group differences in shooting variables were tested individually. In this research, it is visible that there is a statistically significant difference between goalkeepers and drivers in the drive shot variable. The reason for this is their positions throughout the game, while drivers and centers have a minimal difference. Mentioned positions are often trained for shot development, dynamic strength, static strength, leg strength, pass shooting, fake shooting. This indicates that it is an obvious and correct result that the goalkeeper position has weaker results compared to the other two positions of the subjects and that this testing agrees with the real and expected results in water polo.

If they had conducted specific rise from water tests, it is assumed that the goalkeeper would have had significantly better results than the two mentioned positions due to the training plan and program. Furthermore, in a fake shot variable significant difference can be seen in goalkeepers and drivers and goalkeepers and centers. An additional factor of the minimal difference is the genetics of the subjects i.e predispositions and regularity in training. Considering that the tests were performed on 24 subjects, which is not a relatively large sample to take into account additional more precise research, it can be said that these results were expected. In pass shot variable significantly differ goalkeepers and drivers as well as goalkeepers and centers.

All the results of the subjects were obtained in accordance with the conditions at the level of water polo in Bosnia and Herzegovina, which is still in development compared to water polo in Croatia, Serbia and Montenegro. The number of respondents was specially selected for the best individuals from WC „Invictum“. The training system is in a much smaller volume than in the aforementioned countries. In Bosnia and Herzegovina, juniors train six times a week for one hour. This fact alone indicates that there is an expected difference in the results of the subjects comparing Bosnia and Herzegovina and Croatia.

CONCLUSION

The purpose of this paper is to obtain a more detailed statistical analysis and results of one generation of junior water polo players from Sarajevo.

According to morphological analysis the goalkeepers are significantly taller compared to drivers and centers, and also that centers are the players with the highest body mass. Specific shooting tests in water polo were conducted for three different positions, where it was shown that goalkeepers have the weakest shot in water polo compared to center and driver, due to the training and role that goalkeepers have in matches.

These results can be applied in the future in order to improve performance of the future generations involved in water polo, and to raise the level of quality in the sport and therefore progress in the future. On the basis of the obtained results, we should strive to achieve even better results through more efficient and high-quality training.

Certain limitations were also observed. Surprisingly, centers had significantly stronger pass shot compared to the drivers. However, with a small sample size, caution must be applied, as the findings might not be transferable to population of young water polo players. Another source of weakness in this study which could hare affected the measurements was that water polo is not that popular in Sarajevo, as well as the insufficient amount of training for the mentioned generations, and the genetics of the players. Future research should include larger sample of young water polo players and additional specific tests should be included to make the research more complete. Coaches should regularly perform sport specific testing with players in order to be able to more precisely monitor their work and the quality of the training carried out with the players during preparatory and training activities.

REFERENCES

1. Feltner, M. E., & Taylor, G. (1997). Three-dimensional kinetics of the shoulder, elbow, and wrist during a penalty throw in water polo. *Journal of applied biomechanics*, *13*(3), 347-372.
2. Stirn, I., & Strojnik, V. (2006). Throwing with different kinetic chains. *Revista Portuguesa de Ciências do Desporto*, *6*(Suppl 1), 126-127.
3. Uljević, O. (2013): Sport-specific fitness capacity tests in water polo. Doctoral thesis. Faculty of Kinesiology, University of Split.

Pulmonary Function Parameters in Relation to Specific and Generic Aerobic Muscle Capacities in Recreational and Disabled Post-Covid-19 Swimmers

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ABSTRACT

Studies examining the impact of COVID-19 on infected patients have consistently shown that the lungs are the most affected organ. Thus, the objective of this research is to assess the pulmonary function of individuals enrolled in the swimming program who have experienced COVID-19 infection and are dealing with long-COVID conditions. The study investigated 21 persons for anthropometric indices (body mass and height), pulmonary function assessed by spirometry (FVC, FEV1, FEV1/FVC ratio), generic cardiovascular fitness tests (6-minute walk and 30 seconds sit-to-stand), and swimming tests (50- and 100-meters swims). Our participants had average FVC values of 5.23L in males and 3.70L in females, average FEV1 values of 4.23L for males, and 2.68L for females, and an average FEV1/FVC ratio of 81.24% among males, and 73.05% among females, indicating normal pulmonary function parameters. The results of this research support the theory that swimming is beneficial for improving and maintaining the levels of pulmonary function even in patients after respiratory tract infection, such as the COVID-19 infection.

Keywords: Long-COVID, water exercise, spirometry

INTRODUCTION

COVID-19 disease is a respiratory infectious disease, originating in China, rapidly spread globally, becoming a pandemic (Rupani et al., 2020). It was reported that 81% of COVID-19 infections are categorized as mild disease, primarily affecting respiratory tract symptoms such as cough and dyspnea (Demeco et al., 2020). However, the main symptoms of the COVID-19 infection include cough, shortness of breath, general weakness, myalgia, and fever, which can persist long time after the initial infection (i.e., long-COVID). Long-COVID is defined as the presence of symptoms at least 4 weeks after the infection with symptoms lasting for more than 2 months. These long-term effects include cardiovascular (chest pain and tightness), respiratory (cough, shortness of breath) and neurological (headache, dizziness) (Orrù et al., 2021). Additionally, lung diseases are generally known to cause fatigue, impacting daily life and physical activities (Orrù et al., 2021). Therefore, it was expected that active individuals and athletes might experience reduced physical capacities.

Pulmonary sequelae in COVID-19 patients were believed to impair physical fitness, and

this was confirmed in post-hospitalization COVID-19 patients who exhibited lower exercise capacity due to reduced ventilatory efficiency (Skjørten et al., 2021). Furthermore, a study on 105 COVID-19 patients, found that 35% of them had a reduced exercise capacity (VO2 peak was lower than 80% predicted), which was associated with decreased forced vital capacity and total lung capacity (Ribeiro Baptista et al., 2022). Indeed, studies investigating the consequences of COVID-19 on infected patients have consistently shown that the lungs are the most affected organ (Torres-Castro et al., 2021). Specifically, dysfunction in small airways and impaired diffusion capacity have been observed in post-COVID patients (Torres-Castro et al., 2020).

As COVID-19 spread globally, numerous researchers emphasized the importance of exercise in mitigating its negative impacts on general health, particularly on lung functions. Precisely, increasing aerobic capacity has been shown to restore normal lung tissue elasticity, increases ventilation, improves lung mechanics, and decreases lung damage (Mohamed & Alawna, 2020). Additionally, it has been observed that improving aerobic capacity is more effective than breathing exercises for improving pulmonary functions (Evaristo et al., 2020). A recent review study highlighted the importance of introducing pulmonary rehabilitation for patients with compromised lung functions (Siddiq, Rathore, Clegg, & Rasker, 2020). The aquatic environment, specifically, can offer an efficient and safe exercise option for individuals recovering from COVID-19 disease. Precisely, water provides hydrostatic pressure, which enhances the efficiency of the cardiorespiratory system and improves pulmonary function (Dimitrijević et al., 3912). Moreover, swimming, one of the most common water exercises, has been reported to significantly enhance the ability to regulate breathing patterns, including volumes and airflow rates, more effectively than other activities and sports (Cunha et al., 2019).

However, there is a lack of evidence regarding the pulmonary functions of COVID-19 patients included in swimming exercises. Thus, the primary aim of this research was to determine the pulmonary function of individuals included in the swimming program who have experienced long-COVID-19 infection. Additionally, we aim to investigate whether pulmonary function parameters are associated with aerobic capacity, as measured by both generic and swimming-specific tests. The results of this research could insights into the factors influencing the pulmonary functions of post-COVID-19 individuals, thereby facilitating the development of optimized water-based exercise programs for improving pulmonary function.

METHODS

Participants

This research is a part of the project ‘Exercises in water for people after the COVID-19 infection’, financed by the Erasmus sport small-scale partnership with the code 101050089. The project focuses on water-based exercises for individuals recovering from COVID-19. The entire project involved a total of 65 participants. However, for this paper, we analyzed data from 21 individuals (including 7 participants with mental and physical disabilities) who participated in initial testing wave and were actively engaged in water exercises in Zagreb, Croatia. All participants were informed about

the study's aims and protocols and provided informed consent before testing. The ethical board of the Faculty of Kinesiology, University of Split, approved the study (ref. no. 2181-205-02-05-23-004).

Variables and testing procedures

This study included anthropometric indices (body mass, body height), pulmonary function assessed by spirometry, generic cardiovascular fitness tests (6-minute walk and 30 seconds sit to stand), and swimming tests (50- and 100-meter swimming).

Spirometry measures the ability to inhale and exhale air and was conducted using a Vitalograph Micro device (serial number MV15346). It included three parameters: the forced expiratory volume (FVC): This represents the maximal volume of air exhaled with a maximally forced effort expressed in liters, forced expiratory volume exhaled in the first second (FEV1): This is the volume of air exhaled during the first second of the forced exhalation, and the FEV1/FVC ratio: The normal value for this ratio is typically above 0.75-85 (Ranu, Wilde, & Madden, 2011). The spirometry procedure was performed with participants in a in seated position. They were instructed to take a maximal inspiration, followed by a forceful exhalation, continuing until the test was terminated. Each participant underwent three trials with 2 minutes of rest between them, and the highest result was used for further analysis.

The 6-minute walk test (6MWT) was used to assess cardiovascular fitness (i.e., aerobic capacity and endurance). This test is commonly used for evaluating patients with cardiac and pulmonary problems. The test involves measuring the distance covered (in meters) during 6-minute walk, with participants walking from one cone to another placed 30 meters apart (Enright, 2003). The sit-to-stand test was performed using a standard chair. Participants were required to sit and stand up for as many times as possible within the 30 seconds duration. The result of this test is the number of repetitions achieved.

Swimming tests comprised swimming distances of 50 and 100 meters, with participants using their preferred technique, which had to remain consistent throughout the entire distance. The results were recorded as the time taken, expressed in seconds.

The assessment process followed a specific sequence. Participants were initially evaluated for anthropometrics and spirometry. Following this, they underwent a 10-minute warmup, which involved light mobility exercises. Subsequently, they performed the 6-minute walk test. After a 15 minutes rest period, participants completed two swimming tests, with a 5-minute break in between the two swimming sessions.

Statistical analysis

Statistical analysis included presenting descriptive statistics (means and standard deviations). Pearson's correlation coefficients were used to illustrate the correlations between spirometry parameters and swimming and generic fitness tests. The Students T-test for independent samples was used to determine the differences between females and males in study variables. A p-value of 0.05 was applied to all statistical procedures. The statistical package Statistica v.15 was utilized for all analyses.

RESULTS AND DISCUSSION

Descriptive statistics and gender differences in all studied variables are presented in Table 1. It is evident that males exhibited significant

differences in spirometry parameters compared to females. Specifically, males had higher values for FVC, FEV1, and FEV1/FVC ratio than females. However, there were no significant gender differences in any of the physical fitness tests.

Table 1. Descriptive statistics and gender differences in all studied variables.

	Total sample		*Female (n=11)*		*Male (n=10)*		*T-test*	
Variable	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*t-value*	*p-value*
Age (years)	*47.91*	*14.53*	*51.38*	*12.28*	*44.10*	*16.45*	*1.16*	*0.26*
Body height (cm)	*170.71*	*12.02*	*163.22*	*8.06*	*179.82*	*9.78*	*-4.26*	*0.00*
Body mass (kg)	*78.73*	*17.87*	*74.70*	*18.05*	*86.58*	*14.59*	*-1.59*	*0.13*
Heartbeat (number)	*82.27*	*13.25*	*85.82*	*12.85*	*77.40*	*13.18*	*1.48*	*0.15*
Blood oxygen	*96.73*	*1.20*	*97.00*	*1.10*	*96.30*	*1.25*	*1.37*	*0.19*
FVC (litres)	*4.23*	*1.08*	*3.70*	*0.81*	*5.23*	*0.71*	*-4.10*	*0.00*
FEV1 (litres)	*3.23*	*0.94*	*2.68*	*0.59*	*4.23*	*0.44*	*-5.99*	*0.00*
FEV1/FVC ratio (%)	*76.04*	*8.62*	*73.05*	*9.26*	*81.24*	*5.47*	*-2.11*	*0.05*
6min walk test (meters)	*531.90*	*108.34*	*546.09*	*54.56*	*558.67*	*69.64*	*-0.45*	*0.66*
Sit to stand (repetitions)	*12.59*	*3.62*	*13.55*	*2.62*	*12.80*	*2.04*	*0.72*	*0.48*
50m swim (sec)	*89.92*	*51.10*	*98.28*	*57.69*	*68.48*	*21.93*	*1.46*	*0.16*
100m swim (sec)	*197.89*	*72.32*	*204.24*	*29.05*	*169.09*	*50.94*	*1.73*	*0.10*

Correlations between spirometry parameters and swimming, as well as generic fitness tests, are presented in Table 2. Notably, FVC and FEV1 exhibited negative correlations with the swimming 50-meter distance. However, correlations among other variables did not achieve statistical significance.

Table 2. Pearson's correlation coefficients for presenting correlations between spirometry parameters and swimming and generic fitness tests.

Variable	*50m swim*	*100m swim*	*6-minute walk*	*Sit-to-stand*
FVC	*-0.53**	*-0.34*	*0.42*	*0.25*
FEV1	*-0.63***	*-0.48*	*0.40*	*0.21*
FEV1/FVC ratio	*-0.38*	*-0.41*	*0.14*	*0.02*

*denotes $p<0.05$, ** denotes $p<0.01$.

The main findings from this research are: (i) post-COVID-19 individuals had good pulmonary functions, (ii) pulmonary function parameters were associated with swimming tests, and (iii) pulmonary function parameters were not associated with generic aerobic muscle capacities tests.

Participants of our study exhibited favorable pulmonary function parameters values. Normal FVC ranges are typically 4.75-5.5L for males

and 3.25-3.75L for females. In our study, male participants had an average FVC of 5.23L, while females had an average of 3.70L. Similarly, normal FEV1 ranges are around 3.5-4.5L for males and 2.5-3.25L for females. In our study, males had an average FEV1 of 4.23L, and females had an average of 2.68L, all falling within the normal range. The normal ranges for FEV1/FVC ratio is typically 70-85% for both males and 70-85% for females. Our participants exhibited an average FEV1/FVC ratio of 81.24% among males and 73.05% among females, confirming that their pulmonary function parameters were within the normal range. These results can be attributed to the relatively mild to moderate severity of the COVID-19 illness among our participants. They did not require hospitalization, and it's worth noting that 80% of the individuals with COVID-19 experience mild to moderate symptoms (Rodriguez-Morales et al., 2020). Consequently, due to the absence of severe COVID-19 infection in our participants, their pulmonary functions remained in good condition.

Another possible explanation is that our participants engaged in swimming, with some practicing regularly while others did so occasionally. Nevertheless, it is plausible to hypothesize that swimming may have contributed to the preservation of their pulmonary functions. Swimming places substantial demands on inspiratory muscles. The act of being immersed in water and moving through it requires individuals to expand their chests against increased pressure, leading to enhanced inspiratory muscle contraction velocity and strength, as well as increased tidal volume (Cunha et al., 2019). As a result, swimmers are known to exhibit exceptional lung functions and volumes, including a large vital capacity, total lung capacity, and pulmonary diffusion capacity. Furthermore, it has been suggested that swimming may induce similar or even greater adaptations in the pulmonary system compared to isolated training of ventilatory muscles, which is often conducted using devices for flow restriction (Mickleborough, Stager, Chatham, Lindley, & Ionescu, 2008).

Another significant finding from this study is the association between pulmonary function parameters and swimming tests, while no such associations were observed with generic aerobic muscle capacities tests. This finding lends further support to the hypothesis that swimming may be particularly advantageous for enhancing and sustaining pulmonary function when compared to exercises conducted on land. Swimming's unique characteristics, which impose specific demands on the lungs, may explain this association (Cunha et al., 2019).

However, the primary limitation of this study lies in the heterogeneity of the studied sample. Specifically, our sample included individuals with mental and physical disabilities who participated regularly in swimming sessions, as well as individuals without disabilities who occasionally participate in swimming practice. Future research should aim to investigate this topic within more homogenous groups (e.g., only people with disabilities, those without disabilities, and individuals who engage in regular swimming practice). Additionally, it's worth noting that this study is cross-sectional in nature, which means we cannot establish causal relationships or draw precise conclusions about the impact of swimming on pulmonary function parameters.

CONCLUSION

The main findings from this research are that included post-COVID-19 individuals had good pulmonary functions, pulmonary function parameters were associated with swimming tests, while they were not associated with generic aerobic muscle capacities tests. These findings support the theory that swimming is beneficial for improving and maintaining the levels of pulmonary function even in patients after the respiratory tract infection, such as the COVID-19 infection. However, future studies should investigate pulmonary function parameters of the people after respiratory tract infection in a more homogenous group.

REFERENCES

1. Cunha, M., Mendes, F., Paciência, I., Rodolfo, A., Carneiro-Leão, L., Rama, T., . . . Moreira, A. (2019). The effect of inspiratory muscle training on swimming performance, inspiratory muscle strength, lung function, and perceived breathlessness in elite swimmers: a randomized controlled trial. *Porto Biomed J, 4*(6), e49. doi:10.1097/j.pbj.0000000000000049
2. Demeco, A., Marotta, N., Barletta, M., Pino, I., Marinaro, C., Petraroli, A., . . . Ammendolia, A. (2020). Rehabilitation of patients post-COVID-19 infection: a literature review. *Journal of International Medical Research, 48*(8), 0300060520948382. doi:10.1177/0300060520948382
3. Dimitrijević, L., Aleksandrović, M., Madić, D., Okičić, T., Radovanović, D., & Daly, D. (3912). The Effect of Aquatic Intervention on the Gross Motor Function and Aquatic Skills in Children with Cerebral Palsy. *Journal of Human Kinetics, 32*(2012), 167-174. doi:doi:10.2478/v10078-012-0033-5
4. Enright, P. L. (2003). The six-minute walk test. *Respiratory care, 48*(8), 783-785.
5. Evaristo, K. B., Mendes, F. A. R., Saccomani, M. G., Cukier, A., Carvalho-Pinto, R. M., Rodrigues, M. R., . . . Carvalho, C. R. F. (2020). Effects of Aerobic Training Versus Breathing Exercises on Asthma Control: A Randomized Trial. *J Allergy Clin Immunol Pract, 8*(9), 2989-2996.e2984. doi:10.1016/j.jaip.2020.06.042
6. Mickleborough, T. D., Stager, J. M., Chatham, K., Lindley, M. R., & Ionescu, A. A. (2008). Pulmonary adaptations to swim and inspiratory muscle training. *Eur J Appl Physiol, 103*(6), 635-646. doi:10.1007/s00421-008-0759-x
7. Mohamed, A. A., & Alawna, M. (2020). Role of increasing the aerobic capacity on improving the function of immune and respiratory systems in patients with coronavirus (COVID-19): A review. *Diabetes Metab Syndr, 14*(4), 489-496. doi:10.1016/j.dsx.2020.04.038
8. Orrù, G., Bertelloni, D., Diolaiuti, F., Mucci, F., Di Giuseppe, M., Biella, M., . . . Conversano, C. (2021). Long-COVID Syndrome? A Study on the Persistence of Neurological, Psychological and Physiological Symptoms. *Healthcare, 9*(5), 575. Retrieved from https://www.mdpi.com/2227-9032/9/5/575
9. Ranu, H., Wilde, M., & Madden, B. (2011). Pulmonary function tests. *Ulster Med J, 80*(2), 84-90.

10. Ribeiro Baptista, B., d'Humières, T., Schlemmer, F., Bendib, I., Justeau, G., Al-Assaad, L., . . . Boyer, L. (2022). Identification of factors impairing exercise capacity after severe COVID-19 pulmonary infection: a 3-month follow-up of prospective COVulnerability cohort. *Respiratory Research, 23*(1), 68. doi:10.1186/s12931-022-01977-z
11. Rodriguez-Morales, A. J., Cardona-Ospina, J. A., Gutiérrez-Ocampo, E., Villamizar-Peña, R., Holguin-Rivera, Y., Escalera-Antezana, J. P., . . . Sah, R. (2020). Clinical, laboratory and imaging features of COVID-19: A systematic review and meta-analysis. *Travel Med Infect Dis, 34*, 101623. doi:10.1016/j.tmaid.2020.101623
12. Rupani, P. F., Nilashi, M., Abumalloh, R. A., Asadi, S., Samad, S., & Wang, S. (2020). Coronavirus pandemic (COVID-19) and its natural environmental impacts. *International Journal of Environmental Science and Technology, 17*(11), 4655-4666. doi:10.1007/s13762-020-02910-x
13. Siddiq, M. A. B., Rathore, F. A., Clegg, D., & Rasker, J. J. (2020). Pulmonary Rehabilitation in COVID-19 patients: A scoping review of current practice and its application during the pandemic. *Turkish journal of physical medicine and rehabilitation, 66*(4), 480.
14. Skjørten, I., Ankerstjerne, O. A. W., Trebinjac, D., Brønstad, E., Rasch-Halvorsen, Ø., Einvik, G., . . . Ingul, C. B. (2021). Cardiopulmonary exercise capacity and limitations 3 months after COVID-19 hospitalisation. *European Respiratory Journal, 58*(2).
15. Torres-Castro, R., Vasconcello-Castillo, L., Alsina-Restoy, X., Solis-Navarro, L., Burgos, F., Puppo, H., & Vilaró, J. (2021). Respiratory function in patients post-infection by COVID-19: a systematic review and meta-analysis. *Pulmonology, 27*(4), 328-337. doi:10.1016/j.pulmoe.2020.10.013

Quality of Life and Fatigue in Post-Covid-19 Adults with Disabilities Included in The Swimming Practice

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ABSTRACT

INTRODUCTION

Persons with mental and physical disabilities are at greater risk of experiencing a reduced quality of life and heightened levels of fatigue, especially during the pandemic period. It is widely acknowledged that that reduced movement and physical activities during the pandemic are associated with mental and physical health problems. This study aimed to investigate the quality of life and fatigue among adults with disabilities who had recovered from COVID-19 and were actively engaged in swimming practice. **METHODS:** This research included 9 participants who were part of the EU project Post-COV Swim, all of whom had mental and physical disabilities who were actively participating in swimming practice. This study included sociodemographic factors (age, gender, COVID-19 status), as well as anthropometric indices (body mass, body height), multidimensional fatigue inventory (MFI), and quality of life questionnaire (EQ-5D-5L). **RESULTS:** The participants reported a favorable quality of life (scores up to 1.89 out of maximal and worst result of 5 in all subscales) and low fatigue levels (scores up to 10.33 out of maximal 20 in all subscales). Interestingly, there were no significant differences observed in the quality of life and fatigue score between participants who had COVID-19 infection and those who had not. **CONCLUSION:** The findings of this study suggest that participation in swimming has positive impact on individuals with disabilities, whether they have been infected with COVID-19 or not. However, it's important to note that this study had a limited sample size and was cross-sectional in nature. Therefore, future research with a larger and prospective study design is warranted to confirm this positive effect.

Keywords: wellbeing, pandemic, disease, aquatic exercise

INTRODUCTION

The COVID-19 pandemic, declared in 2020, significantly impacted the daily lives and health of infected individuals. Common symptoms of the infection included general fatigue and weakness, shortness of breath, cough, and myalgia, which can last for more than 12 weeks after the initial infection (Orrù et al., 2021). The term 'long-COVID' is used to describe persistent symptoms affecting various organs that continue beyond 12 weeks of the infection. One in three COVID-19 patients experienced one or more long-COVID symptoms 3 to 6 months post-infection. These symptoms encompass breathing difficulties, fatigue, throat and chest pain, myalgia, headache, cognitive symptoms, and depression, often occurring simultaneously and hindering daily activities (Taquet et al., 2021).

Intellectual disability leads to significant limitations in adaptive behaviors and cognitive functioning (Muñoz-López et al., 2023). Additionally, persons with physical disabilities, such as lower extremities amputees, are also at greater risk for experiencing a lower quality of life, especially during the pandemic period. In fact, adults with physical and mobility disabilities from Thailand experienced obstacles in their daily activities, including health care access during the COVID-19 pandemic (Nanthamongkolchai, Tojeen, Munsawaengsub, Yodmai, & Suksatan, 2022). Furthermore, a study examining the quality of life in several countries noted that adult individuals with disabilities experienced a significant reduction in their quality of life during the pandemic (Bidzan-Bluma et al., 2020). It has been reported that reduced movement and physical activities during the pandemic are associated with mental and physical health problems (Dai et al., 2021).

Fatigue is one of the most ongoing symptoms of the long-COVID-19, significantly impairing normal daily functioning. Indeed, a study that investigated patients four months after hospitalization due to the COVID-19 infection recorded high fatigue scores assessed by the Multidimensional Fatigue Inventory scale (Group, 2021). Thus, it is plausible to theorize that individuals with disabilities would also experience increased fatigue as a result of the COVID-19 infection.

Swimming represents a form of physical exercise that is not only pleasurable but also yields positive health outcomes in general. Indeed, swimming has been shown to have beneficial effects on various aspects of physical health (cardiovascular, respiratory, musculoskeletal, and neurological health), as well as overall well-being, physiological effects, and public health (Glasper, 2017). Moreover, aquatic exercise is considered one of the most suitable forms of physical activity for people with intellectual and physical disabilities (Salse-Batán, Suárez-Iglesias, Sanchez-Lastra, & Ayán Pérez, 2023). Specifically, the aquatic environment offers a safe setting due to buoyancy and viscosity, which facilitate mobility and provide an enjoyable and recreational low-impact activity. The reduced weight experienced in the water allows individuals exploring movement patterns without fear of weakness and falling (Salse-Batán et al., 2023). Consequently, aquatic exercise, including swimming, is recommended for people with disabilities to increase their overall physical activity levels and attain good state of health.

However, there is a knowledge gap concerning the quality of life of people with disabilities after recovering from a COVID-19 infection, especially in the context of their participation in swimming practice. Hence, this study aimed to investigate the quality of life and fatigue levels among post-COVID-19 adults with disabilities included in the swimming practice.

METHODS

Participants

This research is a part of the project financed by the Erasmus sport small-scale partnership, titled "Exercises in water for people after the COVID-19 infection", abbreviated as Post-COV Swim, with the project code 101050089. The project's primary focused is on water-based exercises for individuals recovering from COVID-19 and aims to assess their impact on various aspects of participants' well-being (mental, physical, physiological). The complete project involved a total number of 65 participants. However, for this paper, we specifically analyzed 9 participants who have both intellectual and physical disabilities and were part of the initial testing wave. These participants were actively participating in swimming practices in Zagreb, Croatia. All participants were duly informed about the study's aims and protocols and signed informed consent before participating. The ethical board of the Faculty of Kinesiology at the University of Split approved the study (ref. no. 2181-205-02-05-23-004).

Variables and testing procedures

This study included sociodemographic factors (age, gender, COVID-19 status) and anthropometric indices (body mass, body height), assessments of multidimensional fatigue through an inventory, and evaluations of quality of life.

The Multidimensional Fatigue Inventory scale (MFI) was used to assess fatigue levels among participants. The MFI consists of 20 items (questions), each self-reported on a 5-point Likert scale. It encompassed five dimensions (subscales) of fatigue: General Fatigue, Physical Fatigue, Mental Fatigue, Reduced Motivation, and Reduced Activity. MFI scores consist of 5 subscales, each ranging from 4-20 points, in addition to a total score derived from the sum of results across these subscales. The maximum total score of 100 points represents the highest fatigue level, while a score of 20 points represents the highest fatigue level for each subscale (Smets, Garssen, Bonke, & De Haes, 1995).

To assess general health and overall quality of life, the study employed the EQ-5D-5L questionnaire in Croatian language. It consists of five dimensions (subscales): mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each subscale is rated on a scale from 1 to 5, with 1 denoting the highest level of health or the least amount of discomfort and 5 presenting the highest level of discomfort (Feng, Kohlmann, Janssen, & Buchholz, 2021). Both the MFI and EQ-5D-5L questionnaires were administered through an online questionnaire form created in Google Forms, which facilitated the direct export of responses into the Excel spreadsheet.

Statistical analysis

The normality of the data distributions was tested by the Kolmogorov-Smirnov test. Descriptive statistics included means and standard deviations. Given the relatively small sample size, non-parametric statistical tests

were computed. The Mann-Whittney U test was assessed to compare differences between participants who had COVID-19 and those who had not. The Spearman Rank Order Correlation Coefficients were used to assess the correlations between MFI and EQ-5D-5L subscales. All statistical analysis was performed using the Statistica v.13.5 software package, and a p level of 0.05 was applied.

RESULTS

Descriptive statistics and COVID-19 infection differences in all studied variables are summarized in Table 1. In general, participants reported good quality of life and low level of fatigue. No significant differences were observed in any of the included variables between COVID-19-infected and non-infected participants. However, the COVID-19-infected participants tend to have higher scores than non-infected participants in overall fatigue (11.60 vs. 7.75), physical fatigue (10.80 vs. 9.00 for infected and non-infected, respectively), and total MFI score (54.60 vs. 43.25), although these differences did not reach statistical significance. Notably, COVID-19-infected participants also displayed the highest scores on the Pain/discomfort subscale (2.20 vs. 1.25), although these findings did not achieve statistical significance.

Table 1. Descriptive statistics and COVID-19 infection differences in all studied variables are presented in Table 1.

Variable	*Total sample*		*COVID-19-infected*		*Non-infected*		*Mann-Whitney U test*	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Z*	*P-value*
Age (years)	*44.07*	*12.20*	*40.01*	*14.79*	*49.14*	*6.60*	*-1.10*	*0.27*
Body height (cm)	*168.39*	*8.47*	*171.20*	*8.04*	*164.88*	*8.69*	*0.86*	*0.39*
Body mass (kg)	*80.60*	*13.56*	*81.24*	*18.39*	*79.80*	*6.13*	*-0.37*	*0.71*
General fatigue	*9.89*	*3.37*	*11.60*	*1.14*	*7.75*	*4.19*	*1.59*	*0.11*
Physical fatigue	*10.00*	*2.00*	*10.80*	*1.64*	*9.00*	*2.16*	*0.98*	*0.33*
Reduced activity	*10.33*	*3.97*	*11.80*	*2.59*	*8.50*	*5.00*	*1.10*	*0.27*
Reduced motivation	*9.33*	*1.58*	*9.80*	*1.64*	*8.75*	*1.50*	*0.98*	*0.33*
Mental fatigue	*10.00*	*1.87*	*10.60*	*1.52*	*9.25*	*2.22*	*0.86*	*0.39*
MFI total	*49.56*	*10.93*	*54.60*	*5.18*	*43.25*	*13.70*	*0.98*	*0.33*
Mobility	*1.89*	*1.17*	*2.40*	*1.34*	*1.25*	*0.50*	*1.10*	*0.27*
Self-care	*1.56*	*0.88*	*1.80*	*1.10*	*1.25*	*0.50*	*0.49*	*0.62*
Usual activities	*1.56*	*0.88*	*1.80*	*1.10*	*1.25*	*0.50*	*0.49*	*0.62*
Pain/discomfort	*1.78*	*1.09*	*2.20*	*1.30*	*1.25*	*0.50*	*0.98*	*0.33*
Anxiety/depression	*1.63*	*0.92*	*1.80*	*1.10*	*1.33*	*0.58*	*0.30*	*0.77*

The correlations between the Multidimensional Fatigue Inventory and EQ-5D-5L subscales are presented in Table 2. General fatigue was correlated to Mobility, Pain/discomfort and Anxiety/depression subscales. Physical fatigue was found to be associated with Self-care and Usual activities subscales.

Table 2. The correlations between the Multidimensional Fatigue Inventory and EQ-5D-5L subscales.

Variable	*Spearman Rank Order Correlations*				
	Mobility	*Self-care*	*Usual activities*	*Pain/discomfort*	*Anxiety/depression*
General fatigue	*0.84***	*0.55*	*0.55*	*0.86***	*0.76**
Physical fatigue	*0.55*	*0.83***	*0.83***	*0.50*	*0.28*
Reduced activity	*0.48*	*0.66*	*0.66*	*0.48*	*0.33*
Reduced motivation	*0.09*	*0.46*	*0.46*	*-0.01*	*-0.46*
Mental fatigue	*0.13*	*0.37*	*0.37*	*0.08*	*-0.30*

*Note: * denotes p<0.05; ** denotes p<0.01*

DISCUSSION

The most important findings of this study are as follow:

(1) Participants reported a good quality of life and low fatigue levels;

(2) General fatigue was correlated with the Mobility, Pain/discomfort, and Anxiety/depression subscales, while Physical fatigue was associated with the Self-care and Usual activities subscales;

(3) There were no significant differences in the quality of life and fatigue scores between COVID-19-infected and non-infected participants.

The observation that participants had a good quality of life and low fatigue levels can be attributed to their participation in swimming practice, which is known to have broad health benefits. Swimming is recognized as a physical activity with positive effects on the overall health of both healthy and medically compromised individuals (Chase, Sui, & Blair, 2008). Additionally, aquatic exercises, including hydrotherapy, are widely used for the rehabilitation of various musculoskeletal impairments and for improving general health (Becker, 2009). The unique properties of water, such as specific density, affects multiple body systems, including cardiovascular, pulmonary, and musculoskeletal system. Immersion in water leads to increased cardiac output, redistribution of blood flow to the chest cavity, altered respiratory dynamics, and reduced joint impact due to hydrostatic effects (Becker, 2009). Therefore, it is possible that water-based exercises and swimming contributed to the participants improved health outcomes. A study on Spanish adults with intellectual disabilities, also found that engagement in physical activities before the pandemic helped prevent detrimental effects on their quality of life (Muñoz-López et al., 2023). Moreover, the majority of participants in our study had mild intellectual disabilities, further supporting the notion that they experienced good quality of life and low fatigue levels following COVID-19 infection.

Our participants exhibited relatively low levels of fatigue when compared to other studies that assessed post-COVID patients using the same scale (i.e., MFI). Specifically, a study conducted on a cohort of French post-COVID patients reported high scores for reduced motivation and mental fatigue (Group, 2021). However, when we compare our results to the general population of people in Germany, our results are align with them (e.g., the total MFI score was 41.69±17.54 in the German population and 49.56 ± 10.93 in our

participants) (Westenberger, Nöhre, Brähler, Morfeld, & de Zwaan, 2022). Thus, it can be concluded that our participants, despite having physical or mental disability and having experienced COVID-19 illness, had low fatigue levels.

The observed correlation between general fatigue and the Mobility, Pain/discomfort, and Anxiety/depression subscales is logically sound. Regardless, of the pandemic conditions, it expected that general fatigue would lead to impaired everyday functioning, increased discomfort, and anxiety, simply because the individual is unable to carry out their everyday activities as usual. Furthermore, the association between physical fatigue and the Self-Care and Usual Activities subscales further supports the idea that individuals were unable to perform their regular activities as they did before the COVID-19 pandemic.

Additionally, it is possible that the lack of differences in these scores between infected and non-infected participants can be attributed to the fact that all participants were engaged in swimming practices, which likely had a positive influence on their quality of life and fatigue levels, irrespective of their COVID-19 status. However, given the study's small sample size and the absence of prospective monitoring, this can only be hypothesized at this point.

The primary limitation of this study is its small sample size, which limits the ability to establish definitive conclusions. Furthermore, as this is a cross-sectional study, it is not possible to establish causality of the observed relationship. Future research with larger samples, as well as prospective longitudinal designs, will be necessary to confirm and extend these findings.

CONCLUSIONS

The most important findings of this study indicate that participants reported a high quality of life and low fatigue, General and physical fatigue were found to be correlated with most of the MFI subscale scores. Moreover, there were no significant differences in the quality of life and fatigue score between COVID-19-infected and non-infected participants. These results suggest that swimming practice can have a positive impact on individuals with disabilities, regardless of their COVID-19 status. Thus, it may be advisable to include people with disabilities in swimming practice programs to improve their overall health. However, it is important to note that this study had limitations, including a small sample size and a cross-sectional design. Future research with larger and prospective studies is needed to confirm and expand upon these findings are warranted.

REFERENCES

1. Becker, B. E. (2009). Aquatic therapy: scientific foundations and clinical rehabilitation applications. *Pm r, 1*(9), 859-872. doi:10.1016/j.pmrj.2009.05.017
2. Bidzan-Bluma, I., Bidzan, M., Jurek, P., Bidzan, L., Knietzsch, J., Stueck, M., & Bidzan, M. (2020). A Polish and German Population Study of Quality of Life, Well-Being, and Life Satisfaction in Older Adults During the COVID-19 Pandemic. *Frontiers in Psychiatry, 11*. doi:10.3389/fpsyt.2020.585813

3. Chase, N. L., Sui, X., & Blair, S. N. (2008). Comparison of the health aspects of swimming with other types of physical activity and sedentary lifestyle habits. *International Journal of Aquatic Research and Education, 2*(2), 7.
4. Dai, J., Sang, X., Menhas, R., Xu, X., Khurshid, S., Mahmood, S., . . . Alam, M. N. (2021). The Influence of COVID-19 Pandemic on Physical Health–Psychological Health, Physical Activity, and Overall Well-Being: The Mediating Role of Emotional Regulation. *Frontiers in Psychology, 12*. doi:10.3389/fpsyg.2021.667461
5. Feng, Y. S., Kohlmann, T., Janssen, M. F., & Buchholz, I. (2021). Psychometric properties of the EQ-5D-5L: a systematic review of the literature. *Qual Life Res, 30*(3), 647-673. doi:10.1007/s11136-020-02688-y
6. Glasper, A. (2017). Can swimming alleviate the burden of ill health and promote wellbeing? *Br J Nurs, 26*(15), 896-897. doi:10.12968/bjon.2017.26.15.896
7. Group, T. W. C. f. t. C. S. (2021). Four-Month Clinical Status of a Cohort of Patients After Hospitalization for COVID-19. *JAMA, 325*(15), 1525-1534. doi:10.1001/jama.2021.3331
8. Muñoz-López, S., Molina-Garcia, P., Gutiérrez-Cruz, C., Ubago-Díaz, R., Romero-Ayuso, D., & Ariza-Vega, P. (2023). The influence of meaningful activities in the quality of life and functional autonomy of adults with intellectual disability: A prospective study during the COVID-19 pandemic. *J Appl Res Intellect Disabil, 36*(3), 538-546. doi:10.1111/jar.13077
9. Nanthamongkolchai, S., Tojeen, A., Munsawaengsub, C., Yodmai, K., & Suksatan, W. (2022). Quality of Life of Older Adults with Physical and Mobility Disabilities during the COVID-19 Pandemic: A Cross-Sectional Study in Thailand. *Sustainability, 14*(14), 8525. Retrieved from https://www.mdpi.com/2071-1050/14/14/8525
10. Orrù, G., Bertelloni, D., Diolaiuti, F., Mucci, F., Di Giuseppe, M., Biella, M., . . . Conversano, C. (2021). Long-COVID Syndrome? A Study on the Persistence of Neurological, Psychological and Physiological Symptoms. *Healthcare, 9*(5), 575. Retrieved from https://www.mdpi.com/2227-9032/9/5/575
11. Salse-Batán, J., Suárez-Iglesias, D., Sanchez-Lastra, M. A., & Ayán Pérez, C. (2023). Aquatic exercise for people with intellectual disabilities: findings from a systematic review. *Int J Dev Disabil, 69*(2), 134-146. doi:10.1080/20473869.2021.1924033
12. Smets, E. M., Garssen, B., Bonke, B., & De Haes, J. C. (1995). The Multidimensional Fatigue Inventory (MFI) psychometric qualities of an instrument to assess fatigue. *J Psychosom Res, 39*(3), 315-325. doi:10.1016/0022-3999(94)00125-o
13. Taquet, M., Dercon, Q., Luciano, S., Geddes, J. R., Husain, M., & Harrison, P. J. (2021). Incidence, co-occurrence, and evolution of long-COVID features: A 6-month retrospective cohort study of 273,618 survivors of COVID-19. *PLoS Med, 18*(9), e1003773. doi:10.1371/journal.pmed.1003773
14. Westenberger, A., Nöhre, M., Brähler, E., Morfeld, M., & de Zwaan, M. (2022). Psychometric properties, factor structure, and German population norms of the multidimensional fatigue inventory (MFI-20). *Front Psychiatry, 13*, 1062426. doi:10.3389/fpsyt.2022.1062426

Interests and Impediments of Middle School Children to Rowing

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ABSTRACT

The aim of the paper is to determine interests and tendency of middle school children in Vukovar toward rowing, and what are the barriers to participating in this sport. Survey was conducted on 103 respondents in total, ranging in age from 9 to 15 years. The survey consisted of 33 questions divided into 6 categories. The results show that the level of physical activity in children is mostly low, and while they know of the existence of rowing club in Vukovar, most of the respondents prefer polystructural acyclic sports. Conclusively, the reason for low interest in rowing lays in the structure of the sport, and as many as 46,1% of respondents considers rowing as monotonous. The results of the survey also show to the employees of the club the means to improve the strategy of attracting the children to the sport. Rowing as a sport brings many benefits, but it is important to try to change children's view of this sport through presentations and similar activities in the future. Besides physiological benefits, social components such as group traveling and socializing of rowers should be pointed out, as the survey showed them to be important factor when choosing an activity. One of the tools used to animate children could also be social networks which can bring rowing closer to young people and show the attractiveness of this sport.

Key words: interest, strategy, health, Vukovar

INTRODUCTION

Physical inactivity of children and adolescents is the growing problem of modern times. In European and North American countries as many as 81% of children and adolescents is insufficiently physically active. The level of physical inactivity is similar in Croatia, and it should be pointed out that 60% of population is not involved in any form of physical activity (Jurakić and Heimer, 2012). Outdoor activities are more and more frequently exchanged for videogames on computer or mobile phones. There is a very concerning information that Croats spend 612 hours or 25 days a year playing games (Labaš et al., 2019). Physical activity brings many benefits, and students that participate in some physical activity more than 60 minutes a day have more developed motor skills. Physically inactive students, in comparison to those who additionally work out physically in their free time, have higher BMI (body mass index), i.e., higher body mass (Badrić et al., 2015). Regular physical activity in children and adolescents lowers arterial blood pressure, improves motor and functional abilities, and helps achieving optimal body structure. Besides benefits for physical health, physical activity is important for mental health too. It decreases possibility for development of

depression and develops social skills (Krog, 2010). It can be concluded that rowing is ideal activity for children in their free time which can positively affect their health. Considering it physiologically, rowing is an aerobic-anaerobic sport with dominant aerobic component. During rowing competition both anaerobic and aerobic mechanism is under maximum pressure. Since aerobic component prevails, the training should be directed for development of aerobic endurance with optimal ratio of anaerobic and strength training (Mikulić, 2011). Besides aerobic and strength training, rowing training is held outdoors most of the year, so activity in natural environment can benefit the health of children with problems such as asthma, nearsightedness, chronical pain problems, depression, anxiety and even ADHD. (McCurdy et al., 2010).

The aim of this paper is to get feedback from middle school children of the town of Vukovar through survey of their interest in rowing and what are the impediments preventing their participation it that sport.

METHODS

In the survey participated 103 respondents in total, students of the Elementary and middle school of Vukovar (59 boys and 44 girls) ranging from 9 to 15 years in age. Using „Google forms "a questionnaire was composed containing 33 questions divided into 6 categories. The first category contained general questions. The second category of questions was related to the level of physical activity. The third category questioned their knowledge of rowing and achievements of Croatian rowers. The fourth category enquired about their view on rowing. The fifth category surveyed the deficiencies of rowing compared to the other sports, and the last category researched possible impediments or barriers preventing their participation in rowing. The survey was approved by the school principal, and parental consent forms were acquired. The questionnaire was forwarded to teachers, coaches, and finally children to fill out. The participation in the survey was anonymous and voluntary. The data was analyzed through Statistica 14.0. program, and descriptive statistics and particle frequency was used to demonstrate data.

RESULTS

The first category consisted of 5 questions and statements in total, concerning general questions. Results show that most, i. e. 42,8 % of the respondents likes to run, while 28,2 % of them doesn't like to run. 89,3 % of respondents agree with the statement "I like traveling ", while 84,4 % agrees with the statement "I like socializing with other children ".

The other category of questions considers the level of physical activity of the respondents. The results to the first question in this group show that most of the respondents, 74,5% of them, is involved in some kind of physical activity or sport. Most of the respondents participates in physical activity 0 to 5 hours a week, i.e., 35,9 % of the respondents is physically active up to 3 hours a week, and 42,7 % of respondents is physically active 3 to 5 hours a week. Up to 19,4 % of respondents is not participating in even simple exercises, 16,5 % works out once a week, 18,4 % works out twice a week, and 21,4 % of respondents works out three times a week. The respondents that are not physically active, as one of the main reasons state the lack of interest in physical activity (35,9 %), some of them don't have time (12,8

%), only 5 % of them as a reason for inactivity state health problems, and 41 % of the respondents quote some other reasons for not being physically active. Almost all the respondents are aware of rowing as a sport (98,1%) and know that there is a rowing club in Vukovar (88,3%). To the question "Do you know that Croatian rowers achieve top results? ", somewhat smaller number of respondents, but still, most of them (65%) responds with "YES". Regardless of the fact that they know that Croatian rowers achieve top results (65%), they do not know that one of the Olympic gold medalists comes right from Vukovar (59,2%). Even smaller number of the respondents (37,9%) knows that rowers from Vukovar regularly win medals in Croatian Rowing Championship.

There is the divided view of rowing as a sport in the respondents. Most of them (44,6%) stated that they do not like rowing, smaller part (34%) likes it, and 21,4% cannot say that they agree or disagree with the statement. More than half of the respondents, i. e. 54,4% of them stated that they do not find rowing interesting for watching on TV, while only 21,4% of the respondents think that rowing competitions are interesting. That rowing is dull thinks 46,1% of children, and approximately the same number (38,2%) does not think so. Although 45,5% of respondents disagree with the statement that rowing can be excellent extracurricular activity, even 35% of them agrees with it. As many as 27,2% of the respondents stated that they would surely participate in rowing if they knew the influence of rowing on health. Most of the respondents (63,1%) does not see learning the technique as a problem. Every fifth respondent, i. e. 22,3% of them at some point thought about possibility to start with rowing. Most of the respondents (78,7%) disagrees that rowing is exclusively man sport. Only 22,3% of the respondents thinks they are physically too small for rowing. Sports containing more structural movements prefers 57,2% of children, 23,3% of them is undecided, and 19,4% of children prefers monostructural sports. 44,7% of children prefer outdoor sports, while 20,4% of the respondents prefer indoor sports. Ball sports attract more children than sports without ball. Distance to the sport club for 70,9% of respondents is not a problem. Also, the money is not one of the reasons why the respondents do not do rowing (86,3%). Most (75,8%) think that they swim well. Fear of river Danube has 18,5% of the respondents, and 20,3% is afraid of storms during rowing. Parental ban is a problem for only 3,9% of the respondents.

DISCUSSION

Concerning the aim of this research, it is interesting to point out three statements: Even 42,8% of the respondents likes running, 89,3% of them likes traveling and 84,4% of them likes socializing with the other children. Rowing uses running as a part of its condition training. Also, multiple times a year child have the opportunity to compete, and it means the opportunity to travel and socialize on the regattas across Croatia (from Vukovar, Osijek, Zagreb, Karlovac, Ogulin, Pula, Rijeka, Zadar, Split, Metković, Dubrovnik and so on...) and in the world (Croatian Rowing Association, 2023). The other category of questions considered the level of physical activity. 74,5% of the respondents are involved in some kind of physical activity. Furthermore, most of the children is physically active up to 5 hours a week and performs floor exercises 3 times or less a week, and one of the main reasons for inactivity is disinterest. If the level of physical

activity is compared to the WHO recommendations, it can be concluded that most of the children in Vukovar is insufficiently physically active and can be compared to the results given in the Jurakić research (2015). Majority of the respondents know that Croatian rowers achieve top results and almost all know that there is a Rowing Club in Vukovar. The opinion on rowing as a sport is divided in the respondents. Major part (44,6%) stated that they do not like rowing, and smaller part (34%) likes it. Even 46,1% of children think that rowing is dull. What is interesting is that even 35% of the respondents agrees with the statement that rowing would be excellent extracurricular activity. 27,2% of the respondents stated that they would surely participate in rowing if they knew how it positively affects their health, and 22,3% at some point considered the possibility of rowing. Technique learning 63,1% of the respondents does not consider as a problem, 22,3% of the respondents thinks they are physically too small for rowing. The results show that it is important to point out health benefits of this sport during its presentation, and also that there is a possibility of rowing for those who consider themselves physically too small for rowing in the category or light rowers. Besides, pictures of socializing during the training, after training and on the regattas should be used to change the image of rowing as a dull sport in a great number of children (46,1%).

The last group of questions was related to impediments or barriers. The distance to the club for 70,9% respondents is not a problem. Also, the money is not one of the reasons why the respondents do not choose rowing because 86,3% of children disagree with the statement that they do not train rowing because they do not have money for it. The questionnaire was given, besides different sport clubs, to the middle school situated in the center of Vukovar too, so it is not unexpected that the distance to the rowing club is not a problem to the majority of respondents. It can be surmised that if the sample of the respondens were larger and from all the parts of Vukovar, the results would be different. Major part (75,8%) think that they are good swimmers. The fear of Danube River has 18,5% of the respondents, and 20,3% is afraid to be caught in a storm while rowing. Parental ban is a problem for only 3,9% of the respondents. Many children fear Danube (18,5%) compared to the research (Kajgana, 2022) in which only 8% of the respondents stated that they fear water. The difference of the results can be probably explained by higher age of the respondents in that research, ranging from 16 to70 years, so they are probably better swimmers and therefore have lesser fear of water. Parents are not problematic when children want to start with rowing (Lončar, 2021). Out of 216 parents, 148 totally agree, and 41 of them partially agree with including their children in water sports, and most of them (158) chose rowing.

CONCLUSION

Although 74,5% of the respondents (children in the town of Vukovar) participates in some kind of physical activity or sport, comparing the level of physical activity to the recommendations of the World Health Organization it can be concluded that most of the children are insufficiently physically active. They know that there is a rowing club in the town, but they prefer polystructural acyclic sports. The respondents are sufficiently familiar with the rowing as a sport, and unfamiliarity

with the sport is definitely not the reason of their low interest. The fact that they love traveling (89,3% of the respondents) and that they love socializing with other children (84,4% of the respondents) introduces a good basis for the change of opinion on rowing in children. Most of the children and adolescents uses social networks, and quality and informative contents can be used to familiarize children with the essence of rowing, which is not only in the sports results, but also in social events such as traveling, overnight stays, socializing, making new friendships and similar. It all contributes developing of a positive opinion of rowing. Rowing should be also presented as a team sport, taking into consideration that only one class is for single athletes, while in the other categories more athletes are rowing together. Besides this, results show that during the promotion of rowing the importance of physical activity should be pointed out and influence of rowing to the health. Out of all the impediments to rowing, the fear of Danube and of storms came out as the most significant, so it is important to show rowing through presentations as a secure sport, because children are followed by their coach in a speedboat, and in the case of bad weather the training is done in the club indoor area.

Considering all the above, we can conclude that the reason of low interest in rowing arises from the structure of the sport itself, but also insufficient knowledge about the rowing as a sport.

REFEFENCES

1. Badrić, M., Sporiš, G., & Krističević, T. (2015). Razlike u motoričkim sposobnostima učenika prema razini tjelesne aktivnosti u slobodno vrijeme. *Hrvatski športskomedicinski vjesnik*, *30*(2), 92-98.
2. Hrvatski veslački savez. (n.d.). Kalendar natjecanja hrvatskog veslačkog saveza. Available at: https://www.veslanje.hr/dokumenti/kalendar_natjecanja/2023_HVS_Kalendar_natjecanja.pdf, accessed 25.08.2023.
3. Jurakić, D. (2015). Tjelesna neaktivnost – javnozdravstveni prioritet današnjice?. *Hrana u zdravlju i bolesti, Specijalno izdanje* (Štamparovi dani), 9-9. Downloaded from https://hrcak.srce.hr/157096
4. Jurakić, D., & Heimer, S. (2012). Prevalencija nedovoljne tjelesne aktivnosti u Hrvatskoj i u svijetu: pregled istraživanja. *Arhiv za higijenu rada i toksikologiju, 63* (Supplement 3), 3-11.
5. Kajgana, J. (2022). *Stavovi i interesi građana grada Našica i okolice o osnivanju centra sportova na vodi na jezeru Lapovac* (Diploma paper). Faculty of Kinesiology, Zagreb.
6. Krog, D. (2010). Pozitivni učinci tjelesnih aktivnosti. *Djeca u Europi: zajednička publikacija mreže europskih časopisa*, *2*(4), 4-5.

7. Labaš, D., Marinčić, I., & Mujčinović, A. (2019). Percepcija djece o utjecaju videoigara. *Communication Management Review*, *4*(01), 8-27.
8. Lončar, P. (2021). *Mišljenje građana karlovačke županije o izgradnji centra sportova na vodi* (Diploma paper). Faculty of Kinesiology, Zagreb.
9. McCurdy, L. E., Winterbottom, K. E., Mehta, S. S., & Roberts, J. R. (2010). Using nature and outdoor activity to improve children's health. *Current problems in pediatric and adolescent health care*, *40*(5), 102-117.
10. Mikulić, P. (2011) Fiziološka analiza veslanja /on line/. Downloaded from the internet on August 25th, 2023. available at https://www.mladost.hr/Uploads/1/2/491/725/TrenerskiSeminar_FizioloskaAnalizaVeslanja.pdf

Gender Differences in Improving Balance on Aquatic Fitness Floating Mat

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ABSTRACT

The aim of the study was to see the gender differences in improving balance by training on water floating mats. The participants in the study were kinesiology students, N=49, 27 female and 22 males, aged 23,78±2,69 years. Twice a week, all of them participated in six weeks training program. Before entering and after finishing the training program, basic dynamic and static balance were tested on BIODEX platform. After statistical analysis the results showed that in both, initial and final testing female performed better results in static and dynamic balance. During the training process, at most of the variables all of them improved, but women improved more considering the body structure and mobility of lower limbs. Future studies should include more analyses to find more exact reasons for gender differences in balance.

Keywords: balance training, fitness trend, swimming pool

INTRODUCTION

In general, Balance is defined as the ability to maintain the body's center of gravity within its base of support. Maintaining the position in the balance requires effective integration of visual, vestibular, and proprioceptive inputs to produce an efferent response to control the body within its base of support (Guskiewicz & Perrin 1996., Irrgang, Whitney, & Cox, 1994.). We differ dynamic and static one. It is considered that the Dynamic is more challenging because it requires the ability to maintain equilibrium during a transition from a dynamic to a static state (Ross & Guskiewicz, 2004). In opposite to static balance which is considered as the ability to sustain the body in static equilibrium or within its base of support (Goldie at all 1989., Olmsted et all 2002.). An interruption or deficit in any part of the sensorimotor system can result in a loss of balance, which can result in injury. But improving balance with training in a healthy population has positive effects with reducing injury. (DiStefano, Clark, & Padua, 2009.). Balance training is more common to professional athletes or it is a critical and frequent objective of rehabilitation and injury prevention programs. While there is substantial evidence that performing exercise on unstable surfaces can induce substantial core (trunk) and limb joint muscle activation (Behm & Colado 2012., Anderson & Behm 2005.) balance training is rarely aimed training in various fitness programs. Mostly trained are strength, power, mobility and functional abilities, but the balance is a bit neglected and trained superficially.

Following last trends in fitness industry, we can do some improvement in balance field with aquatic fitness, precisely with training on water floating mats. Those mats are designed for individual or group classes in the swimming pool. The training is performed on the floating mat, which is fastened with rope to the edge of the pool. The unstable surface of the water presents a real challenge in any body position so it makes any type of training, balance training also. Variety of fitness workouts could be trained, from Yoga and Pilates, the steady ones, up to dynamic ones like HIIT exercises. By exercising on floating mat deep core muscles are engaged, and all muscle groups work to counterbalance the unstable and unpredictable movement of the mat. Considering the water environment, combining relaxation and intensity training mode, and considering all the benefits of the water exercise, could conclude that the floating training mats are desirable fitness program. This type training program is conducted at Faculty of Kinesiology in Split as a part of regular classes of the subject Aquatic fitness. Following written, the aim of the study was to see the gender differences in improving balance by training on water floating mats.

METHODS

The participants in the study were kinesiology students, N=49, 27 female and 22 males, aged 23,78±2,69years. Before entering and after finishing the training program, students were tested on Biodex Balance System SDTM (Biodex medical Systems, NY, USA) (Pavlinovic, Foretic, & Versic, 2021). Among other standardized tests, the Limits of Stability Test (LST) and the Postural Stability Test (PS) are most popular Biodex tests for balance monitoring (Cachupe, Shifflett, Kahanov, & Wughalter, 2001). PS is used to assess static balance. During PS performance, the subject stands with one or two legs on an unstable platform, and his task is to minimize the movement of the platform with timely and precise muscle contraction (Aydoğ, Aydoğ, Cakci, & Doral, 2006). In the PS that our participants performed, they needed to maintain static balance position for 30 seconds while standing on two feet in the center of the platform. Before the test the position of the subjects' feet is recorded. The result on the test shows a deviation from the center. Smaller results values are and presented with Balance in- dex. LST assess dynamic balance. During test performance subject controls his body's' center of gravity and manipulates/moves the platform in a desired direction (Glave, Didier, Weatherwax, Browning, & Fiaud, 2016). In the LST, participants had to move the body to bring the cursor on the screen to the blinking targets and return the cursor to the center as soon as possible with as less deflection possible. This was repeated randomly with 9 targets position in circle around the center target. LST BI is calculated with Biodex software. Higher BI indicates better dynamic stability result. After initial testing in laboratory, students attended the training program. Twice a week, for six weeks total. During the 35-45 min training program they did static and dynamic exercises which, except developing balance, included strength and mobility exercises, playing games and having fun of floating mats. Statistical analysis included descriptive with normality distribution and T-test for finding the gender differences in tested variables. Body height and body weight were measured at the beginning and at the end of the program, and no changes occurred in 5 weeks in those variables. Tests on Biodex were performed again after conducted six-week training program.

RESULTS AND DISCUSSION

Table1. presents the results of descriptive statistics. Observing the Kolmogorov-Smirnov test calculation, all variables have a normal distribution and are therefore suitable for application of parametric statistical methods.

Table1: Descriptive statistics for measured variables (N=49)

Variable	N	AS	SD	Min	Max	max D	K-S p
PS	49	1,32	0,49	0,50	2,63	0,16	p < ,20
LST	49	24,14	10,45	4,00	51,00	0,15	p > .20
BH	49	174,43	10,81	150,00	194,00	0,08	p > .20
BW	49	70,68	13,28	47,00	104,00	0,07	p > .20
AGE	49	23,78	2,69	19,00	32,00	0,12	p > .20
PS F	49	1,00	0,49	0,40	2,90	0,17	p < ,15
LST F	49	30,02	12,17	6,00	55,00	0,11	p > .20

***Legend**: **AS**-arithmetic mean; Min-minimum result; Max-maximum results; **SD**-standard deviation; **Max D**-test value of Kolmogorov-Smirnov test; **K-S p**-Kolmogorov-Smirnov test, PS-postural stability, LST-limits of stability, Bh-body height, BW-body weight, AGE-age of participants, PS F- postural stability final measurement, LST F-limits of stability final measurement.*

Observing numbers in each variable, it has to be accented that the lower numbers on PS test means better result. Also, the larger number in LST means better result on that test. According to similar studies, just by observing the numbers, we cannot say if those results are good or bad, but we can state the differences in initial measurement and the final one. From beginning to the end of the study process students improved their results. But observing the Table2., we can see some differences in results according to gender.

Table 2: T test between genders for balance variables

Variable	AS M	AS F	t-value	p
PS	1,53	1,15	2,92	0,01*
PS F	1,67	0,78	2,34	0,02*
LST	20,14	27,41	-2,56	0,01*
LST F	24,27	34,70	-3,27	0,00*

Legend:* AS *M*-*arithmetic mean male;* AS *F*-*arithmetic mean female*, t-value-**T** test value **p-level** *of significance;* **-statistically significant result at p<0.05

In Table2 we can see that there are statistically significant differences between male and female in initial testing of postural stability (PS) which is considered as static balance. Due to the fact that men and women differ anatomically and physiologically, the balance ability of men and women have been compared by many researchers based on the idea that there may be differences between the balance ability of men and women (Akinoğlu, et al 2023.) Reviewing the literature, it is stated that due to an anatomical and physiological differences between men and women, women's balance skills are better than men (Condon & Cremin, 2014). Also, it is believed that the female adolescents present better postural balance than male individuals due to the different anthropometric characteristics (Dorneles et al 2013). Some authors state that mass distribution is different in female bodies due to morphological factors, thus lowering their CG in relation to male individuals with the same height, also decreasing postural oscillation values (Lemos et al 2009). There are also differences in final testing (PS F), but it is obvious that male students decreased the result in their PSF. The real reason for decreasing result is unknown. Observing their ability on the floating mat leads to better performance of the exercises and tests. But the motivation for testing sometimes makes the problem. From the beginning of the study, male students have problems with motivation. Considering that they are stronger and more muscular than female they have to perform something that they are not good at, and above that, they are "weaker" than female students in doing that. Although through training process they did all the assignments and exercises, the fact that they are constantly worse than female has some bad effect on their motivation. Results statistically differ from initial to final testing for the dynamic balance (LST) between male and female. In this one, both of the groups improved their results. Observing the movement while exercising, dynamic balance is constantly involved. Even in those exercises when the movement is considered to be static, still the mat on the water is moving unpredictably and gives the body dynamic feedback. That is the reason why the results got better for both groups, since they practiced dynamic balance through almost whole training process.

CONCLUSION

Although the results of the research showed that training on water floating boards has a positive effect on the development of static and dynamic balance of the basic type, it is obvious that better results and a greater impact were found in the dynamic manifestation of this ability. The reason for the mentioned phenomenon should be found in the structure of the training program, but also in the execution of the exercises used in it. Namely, all the exercises that were performed during the implemented program, regardless of the formal categorization, were dominantly of a dynamic character. Just maintaining balance on a floating board, without additional disturbance of the balance position, requires a much greater proprioceptive engagement from the exerciser than it is on platforms that are on solid surfaces such as parquet or concrete (Zech et al., 2010). Considering the aim of the study, significant differences between genders in static and

dynamic balance were shown. Like in previous, in this study, female students also performed better than their male colleagues. But since the balance is a bit neglected ability in fitness training, this study showed good improvement in static and dynamic balance no matter the gender. Moreover, given the exercises and games used in the training program confirm the balance improvement. All confirming that exercise program on the water floating mats are desirable new and fun way of enhancing fitness performance same as motor abilities.

REFERENCES

1. Akinoğlu, B., Acar, H. Y., Paköz, B., & Kocahan, T. (2023). Comparison of static and dynamic balance ability according to gender in athletes-a cross sectional study. *Turkish Journal of Kinesiology*, *9*(2), 91-98.
2. Anderson K, Behm DG. Trunk muscle activity increases with unstable squat movements. Can J Appl Physiol. 2005; 30:33–45. https://doi.org/10.1139/h05-103.
3. Aydoğ, E., Aydoğ, S., Cakci, A., & Doral, M. (2006). Dynamic postural stability in blind athletes using the biodex stability system. International journal of sports medicine, 27(05), 415-418.
4. Behm D, Colado JC. The effectiveness of resistance training using unstable surfaces and devices for rehabilitation. Int J Sports Phys Ther. 2012;7:226–41.
5. Cachupe, W. J., Shifflett, B., Kahanov, L., & Wughalter, E. H. (2001). Reliability of biodex balance system measures. Measurement in physical education and exercise science, 5(2), 97-108.
6. Condon, C., & Cremin, K. (2014). Static balance norms in children. Physiother Res Int, 19(1), 1-7.
7. DiStefano, L. J., Clark, M. A., & Padua, D. A. (2009). Evidence supporting balance training in healthy individuals: a systemic review. *The Journal of Strength & Conditioning Research*, *23*(9), 2718-2731.
8. Dorneles, P. P., Pranke, G. I., & Mota, C. B. (2013). Comparação do equilíbrio postural entre adolescentes do sexo feminino e masculino. Fisioterapia e Pesquisa, 20(3), 210–214. https://doi.org/10.1590/S1809-29502013000300003
9. Glave, A. P., Didier, J. J., Weatherwax, J., Browning, S. J., & Fiaud, V. (2016). Testing postural stability: are the star excursion balance test and Biodex Balance System limits of stability tests consistent? Gait & posture, 43, 225-227.
10. Goldie, PA, Bach, TM, and Evans, OM. Force platform measures for evaluating postural control: Reliability and validity. *Arch Phys Med Rehabil* 70: 510-517, 1989.
11. Guskiewicz, KM and Perrin, DH. Research and clinical applications of assessing balance. *J Sport Rehabil* 5: 45-63, 1996.
12. Irrgang, JJ, Whitney, S, and Cox, E. Balance and proprioceptive training for rehabilitation of the lower extremity. *J Sport Rehabil* 3: 68-83, 1994.

13. Lemos LFC, Teixeira CS, Mota CB. Uma revisão sobre centro de gravidade e equilíbrio corporal. Rev Bras Ciên Mov. 2009;17(4):83-90.
14. Olmsted, LC, Carcia, CR, Hertel, J, and Shultz, SJ. Efficacy of the star excursion balance tests in detecting reach deficits in subjects with chronic ankle instability. *J Athletic Train* 37: 501-506, 2002.
15. Pavlinovic, V., Foretic, N., & Versic, S. (2021). Association of Laboratory and Field Balance Test. *Sport Mont*, *19*(3), 65-68.
16. Ross, SE and Guskiewicz, KM. Examination of static and dynamic postural stability in individuals with functionally stable and unstable ankles. *Clin J Sport Med* 14: 332-338, 2004.
17. Zech, A., Hübscher, M., Vogt, L., Banzer, W., Hänsel, F., & Pfeifer, K. (2010). *Balance training for neuromuscular control and performance enhancement: a systematic review*. Journal of athletic training, 45(4), 392-403.

The Teosq Questionnaire for Target Motivational Orientation in Young Swimmers and Gender Differences

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ABSTRACT

The main objective of this study was to identify the motivational orientation of 42 young swimmers: male (N = 19, mean age = 16,47) and female (N = 23, mean age = 15,87). All swimmers completed the CTEOSQ questionnaire. Kolmogorov- Smirnov and T-test were used for the data analysis. The results led to the conclusion that swimmers are more task-oriented, as per both male and female swimmers. When comparing two groups, some significant gender differences were found in task orientation, where female respondents have greater values. It can be recommended that future research on competitive athlete should use different methodologies to identify motivational orientation, and the link between motivational orientation and level of competition. This will uncover numerous different reasons for motivational orientation which will provide coaches the most efficient methods while working with the athletes.

Keywords: athletes, swimming, juniors, cadets, goals

INTRODUCTION

Motivation plays a crucial role in achieving success in sports. Every athlete, regardless of their experience level, must understand their motivational factors. Motivation often varies among athletes and can be essential for their athletic progress. Some authors argue that the socio-cognitive approach provides two fundamental goal perspectives, ego and task orientation. The social-cognitive approach to achievement motivation presumes two basic perspectives of modeling achievement goals. At the same time, these perspectives are the criteria by which an individual assesses success in achievement context (Duda, 1992; Duda & Nicholls, 1992; Roberts & Bengtson, 1993; Barić & Horga, 2006). These achievement goals are mutually contrasted as the task- versus the ego-orientation. Whether a person is in a state of task or ego-involvement in the achievement context of a sport activity depends on his/her dispositional orientation (Duda, & Hom, 1993; Roberts & Treasure, 2012). Task- and ego-goal orientations are considered as orthogonal dimensions (Duda & Hall, 2001) and a person can be high or low in either or both. If an athlete's primary goals are the mastery of sport skills, learning and improving through the effort invested (task-goal orientation), it is more likely, according to the achievement goal theory, that his/her intrinsic motivation is higher (Duda & Hall, 2001; Treasure & Schmidt 2001). On the other hand, if an athlete's primary goals are winning, exceeding others, results, and medals (ego- goal orientation), there is much more risk of developing an extrinsic motivation pattern. It may have some negative

consequences, as for example, maladaptive responses or diminishing motivation, especially when results and winning fail and it is especially the case for athletes with a lower perceived competence (Barić & Horga, 2006). One of the most important questions is how to motivate young athletes. Swimming is one of the sports that attracts many young talents. Young swimmers require special attention to preserve and develop their sports motivation. The Task and Ego Orientation in Sport Questionnaire (TEOSQ) is a tool that can help in understanding the motivation of young swimmers. The TEOSQ is a widely used measure of goal orientation, its validity and reliability have been supported in many studies. This questionnaire provides insight into whether young swimmers are more focused on achieving results or enjoying the act of swimming itself. Understanding the target orientation of young swimmers can assist coaches in adapting their methods and supporting their development. In the following sections of the paper, we will explore how the TEOSQ questionnaire can be a valuable tool in enhancing the motivation and performance of young swimmers. Furthermore, TEOSQ translated into the Croatian language and used within the national sport-specific environment is also a valid and reliable instrument. It is suitable for use within a sport context with young, as well as with experienced athletes (Barić & Horga, 2006).

The aim of the study was to determine the structure of goal orientation in young swimmers, based on gender, using the Croatian Task and Ego Orientations in Sport Questionnaire (CTEOSQ).

METHODS

A total of 42 young Croatian athletes (mean age = 16.14) volunteered to participate in the study. The sample was comprised of 19 male (N = 19, mean age = 16,47) and 23 female (N = 23, mean age = 15,87) athletes from Croatian swimming clubs. Swimmers competed at a regional, national, European or world level. All the respondents have been members of their clubs for at least 2 years and trained in their clubs at least five times per week. All the respondents were asked to complete the Croatian version of the Task and Ego Orientation in Sport Questionnaire (CTEOSQ; Barić & Horga, 2006). The original Task and Ego Orientation in Sport Questionnaire (Duda et al., 1995) comprises of two goal orientation dimensions, which reflect the task and ego-goal constructs suggested by the achievement goal theory (Duda & Nicholls, 1992). Many studies have consistently supported its construct validity and reliability (Duda & Hall, 2001; Barić & Horga, 2006). Before completing the questionnaire, the club's management, coaches, as well as parents were informed. The data was collected via QR code that coaches showed to the swimmers. All the respondents filled in the questionnaire. The participants were asked to respond to CTEOSQ regarding their participation in their team in the current competitive season, while anonymity and confidentiality of the athletes' responses were guaranteed.

RESULTS and DISCUSSION

In Table 1 descriptive statistics for all the respondents are shown.

Table 1. Descriptive statistics of all respondents

Var	*Valid N*	*M*	*Min*	*Max*	*SD*
A	*42*	*16,14*	*15,00*	*19,00*	*1,16*
BH	*42*	*176,52*	*161,00*	*192,00*	*8,76*
BW	*42*	*64,93*	*47,00*	*90,00*	*10,61*
EO	*42*	*3,20*	*1,17*	*5,00*	*0,90*
TO	*42*	*4,44*	*3,43*	*5,00*	*0,41*

Legend: A- Age (years); B- Body Heigh (cm); BW- Body Weight (kg); E- Ego Orientation; T- Task Orientation, Var- Variable; Valid N- Number of Respondents; M-Arithmetic Mean; Min- Minimum Value; Max- Maximum Value; SD- Standard Deviation

From Table 1 it can be concluded that all variables have normal values and have been normally distributed. Standard deviation has larger values at BW (body weight); SD= 10,61, which is normal due to all participants, male and female have been taken into consideration. Also, it can be concluded for BH (body height), as male respondents have greater values and SD= 8,76.

Table 2. Descriptive statistics of male respondents

Var	*Valid N*	*M*	*Min*	*Max*	*SD*
A	*19*	*16,47*	*15,00*	*19,00*	*1,26*
BH	*19*	*183,05*	*165,00*	*192,00*	*6,92*
BW	*19*	*71,53*	*47,00*	*90,00*	*10,50*
EO	*19*	*2,99*	*1,17*	*4,33*	*0,82*
TO	*19*	*4,29*	*3,43*	*4,86*	*0,39*

As for motivational orientation, we can see that swimmers are more task oriented (TO= 4,44), comparing to ego (EO= 3,20). These results have also been confirmed by authors who have researched a variety of sports. Croatian football and handball players are more task- than ego-oriented, which is considered as a more desirable orientation for formulating achievement goals in sport (Barić & Horga, 2006).

In Table 2 we can see descriptive statistics for male respondents only.

Table 2, it can also be seen that all variables have normal values and have been normally distributed. Standard deviation has larger values at BW (body weight); SD= 10,50 and BH (body height) variable; SD= 6,92. These results can be explained with the fact that both cadet and senior swimmers have been participating in this research, while senior swimmers are older and have developed musculoskeletal system. Regarding motivational orientation, male swimmers have mostly been task- oriented, in contrast to the ego (TO= 4,29; EO= 2,99).

In Table 3 descriptive statistics for female respondents are shown.

Table 3. Descriptive statistic of female respondents

Var	*Valid N*	*M*	*Min*	*Max*	*SD*
A	*23*	*15,87*	*15,00*	*18,00*	*1,01*
BH	*23*	*171,13*	*161,00*	*182,00*	*6,06*
BW	*23*	*59,48*	*48,00*	*76,00*	*7,15*
EO	*23*	*3,37*	*1,67*	*5,00*	*0,95*
TO	*23*	*4,57*	*3,71*	*5,00*	*0,39*

Table 3 shows that all variables have been normally distributed. Standard deviation has larger values at BW (body weight); SD= 7,15 and BH (body height) variable; SD= 6,06. These results can also be explained as for the male group. Regarding motivational orientation, female swimmers have also been more task- oriented than the ego (TO= 4,57; EO= 3,37).

Table 4 shows Frequency Tables of the highest level of competition among respondents.

Table 4. Frequency Tables of the highest level of competition among respondents

Cat	*Cou*	*Cum*	*Per*	*Cum*
R	*3*	*42*	*7,14*	*100,00*
N	*33*	*33*	*78,57*	*78,57*
E/W	*6*	*39*	*14,29*	*92,86*
M	*0*	*42*	*0,00*	*100,00*

Legend: R- Regional level of Competition; N- National level of Competition; E/W- European or World level of Competition; M- Missing from state, Cat- Categorie; Cou- Count Number; Cum-Cumulative Number; Per- Percent; Cum- Cumulative

From Table 4 the highest level of competition among all respondents is a national level (N=33), while some of them competed at European or world championships (N=6) and the rest of them competed at a regional level (3).

Table 5 shows Test of Normality for male respondents.

Table 5. Test of Normality for male respondents

Var	*N*	*Max D*	*K-S*
EO	*19*	*0,082837*	*p > 0,20*
TO	*19*	*0,128328*	*p > 0,20*

Legend: E- Ego Orientation; T- Task Orientation

In Table 5 it is shown that for male respondents both variables EO (ego- oriented) and TO (task- oriented) are normally distributed with Kolmogorov- Smirnov test values (p> 0,20).

From Table 6 Test of Normality for female respondents can be seen.

Table 6. Test of Normality for female respondents

Var	*N*	*Max D*	*K-S*
EO	*23*	*0,124149*	*p > 0,20*
TO	*23*	*0,213643*	*p < 0,20*

Legend: E- Ego Orientation; T- Task Orientation

By looking at Table 6, also for the female respondents, variables EO (ego- oriented) and TO (task- oriented) are normally distributed with Kolmogorov- Smirnov test values (EO; p> 0,20 and TO; p< 0,20).

In Table 7 T-test for two groups, male and female swimmers have been shown.

Table 7. T-test for two groups of respondents

Var	*M- M*	*M- W*	*t-val*	*df*	*p*	*Valid N- M*	*Valid N- W*	*SD- M*	*SD- W*
EO	*2,99*	*3,37*	*1,37*	*40*	*0,18*	*19*	*23*	*0,82*	*0,95*
TO	*4,29*	*4,57*	*2,24*	*40*	*0,03*	*19*	*23*	*0,39*	*0,39*

Legend: E- Ego Orientation; T- Task Orientation, M- M-Arithmetic Mean for Male Respondents; M- W- Arithmetic Mean for Female Respondents; t- val- t- value; df- Degrees of Freedom; p- Level of Significance; Valid N- M- Number of Male Respondents; Valid N- W- Number of Female Respondents; SD-M- Standard Deviation for Male Respondents; SD-W- Standard Deviation for Female Respondents

By looking at a Table 7, there is a statistically significant difference between the two groups, in variable TO (p= 0,03). We can see that both men and women have larger values at TO, than the EO. It is also evident that female respondents have some greater values at both variables than the male.

From all the above mentioned, no gender differences were found in orientation, indicating that male and female athletes have an

equal approach to participating in the sport of swimming. This finding is consistent with the research of Šarić (2023). On the other hand, there are some differences regarding TO between men and women, because women have greater values of a mentioned variable. Also, these findings are opposite to some other research which have been conducted on athletes and suggests that male athletes are more performance-oriented, while female athletes are more task-oriented (Duda & Hall, 2001).

Furthermore, authors Šilić, Crnjac & Lovrić (2019) presented in their work that young swimmers are more task-oriented in swimming, perceive themselves as competent in the sport, and are oriented towards social recognition, expressing higher levels of satisfaction in swimming than their peers in this sport. Satisfaction in swimming is significantly and negatively correlated with outcome orientation but is not related to social status and social connectedness.

In addition to previously mentioned, Kuterovac (2022) claims that athletes show a high level of self-esteem, on average they are more oriented towards the task and the improvement of skills, but the goal orientation towards the outcome and result is also expressed.

Considering all the above, it is necessary to conduct further research to determine motivational orientation within young competitive athletes, as well as the reasons for such orientation, for coaches to obtain results that they could apply in their work. Researchers should be encouraged to employ different methodologies and prioritize underused topics in future research on competitive athlete groups (Clancy, Herring, Mac Intyre, & Campbell, 2016).

CONCLUSION

In this study, no gender differences were found in motivational orientation among young swimmers, indicating that male and female athletes have an equal approach to participating in the sport of swimming. When comparing two groups, some significant gender differences were found in task orientation, where female respondents have greater values.

In conclusion, different methodologies should be used to identify motivational orientation, and the link between motivational orientation and level of competition. This will uncover numerous different reasons for motivational orientation which will provide coaches the most efficient methods while working with the athletes.

REFERENCES

1. Barić, R. i Horga, S. (2006). Psychometric properties of the Croatian version of task and ego orientation in sport questionnaire (cteosq). *Kinesiology, 38* (2.), 135-142. Preuzeto s https://hrcak.srce.hr/9075
2. Clancy, R.B., Herring, M.P., MacIntyre, T., & Campbell, M.J. (2016). A review of competitive sport motivation research. *Psychology of Sport and Exercise, 27*, 232-242.
3. Duda, J. L. (1992). Motivation in sport setting: A goal perspective analysis. *Motivation in sport & exercise*, 7-91.
4. Duda, J. L., & Nicholls, J. G. (1992). Dimensions of achievement motivation in schoolwork and sport. *Journal of educational psychology*, *84*(3), 290.
5. Duda, J., & Hall, H. (2001). Achievement goal theory in sport: Recent extensions and future directions. In *Handbook of sport psychology* (pp. 417-443). John Wiley & Sons.
6. Duda, J. L., & Hom, H. L. (1993). Interdependencies between the perceived and self-reported goal orientations of young athletes and their parents. *Pediatric Exercise Science*, *5*(3), 234-241.
7. Kuterovac, P. (2022). *Psihološki čimbenici povezani s dopingom u sportu* (Doctoral dissertation, University of Zagreb. Faculty of Kinesiology).
8. Roberts, R. E., & Bengtson, V. L. (1993). Relationships with parents, self-esteem, and psychological well-being in young adulthood. *Social psychology quarterly*, 263-277.
9. Roberts, G. C., & Treasure, D. (2012). *Advances in motivation in sport and exercise*. Human Kinetics.
10. Treasure, J., & Schmidt, U. (2001). Ready, willing and able to change: Motivational aspects of the assessment and treatment of eating disorders. *European Eating Disorders Review: The Professional Journal of the Eating Disorders Association*, *9*(1), 4-18.
11. Šarić, P. (2023). Ciljne orijentacije mladih sportaša u funkciji dobi: *presječno istraživanje* (Doctoral dissertation, University of Split. Faculty of Humanities and Social Sciences, University of Split).
12. Šilić, N., Crnjac, D., & Lovrić, F. (2019). Ciljna orijentacija i socijalna motivacija kao prediktori zadovoljstva u plivanju. *U: Babić, V.(ur.), Zbornik radova*, *28*, 610-617.

Differences in Motivation for Exercise Between Male and Female High School Students

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ABSTRACT

Non-movement is one of the biggest issues of today, therefore it is necessary to try to motivate as many people as possible to have an active lifestyle. This is the reason why motivation for exercise ought to be studied. The purpose of this research is to establish the differences in exercise motivation regarding sex. Exercise motivation has been assessed by Croatian version of EMI – 2 (Exercise motivation inventory – 2) consisting of 14 motives (factors): weight management, health avoidance, revitalization, appearance, social recognition, stress management, health, strength and endurance, enjoyment, affiliation, health pressures, competing, nimbleness and challenge. The research has been done on the sample of 240 high school students at the Civil Engineering and Geodesy Technical School, and Design, Graphics and Sustainable Civil Engineering School in Split. The total sample has been divided by sex in subsamples, thus there are 165 female and 75 male students. Mann-Whitney U test was used to determine the difference between sexes. The obtained results evidently reveal that all the respondents in this research stated the following motives as the most essential ones: health, strength and endurance followed by revitalisation motive. The least important motives were social recognition and affiliation. Seven out of fourteen factors indicated statistically significant difference with regard to sex. Weight management, health avoidance, revitalisation, stress management and health are the most significant factors for exercise motivation in female students compared to male students. Compared to the female population, male students exercise motivating factors are competition factor and affiliation.

Key words: EMI-2, high school, physical activity, survey

INTRODUCTION

Non-movement is one of the greatest issues nowadays, thus it is essential to try to motivate as many people as possible to have an active lifestyle. It is a well-known fact that physical activity is important at every age while increasing physical activity in insufficiently active both young and older population is an important health issue. Word Health Organization (WHO) defines physical activity as "all movements caused by activating skeleton muscles which require energy consumption".

Physical activity is a term describing every physical movement which requires any kind of muscle contraction and which results in the increase of energy consumption bigger than the one in a standstill (Misigoj-Durakovic et al., 2018). Engagement in physical activity may largely contribute to health, psychological well-being and general life quality. Data reveal that 75% of adolescents do not follow present guidelines (60 minutes of moderate to intensive activity most of the days in a week) for activity (Fakhouri et al, 2012). There are strong scientific evidence of negative connection between physical activity and heart conditions (Conroy et al. 2005; Kubota et al. 2017), high blood pressure, stroke, type 2 diabetes, metabolic syndrome, colon cancer and breast cancer (Bauman et al. 2002; Chen and Millar, 2001; Staurt and Nanette, 2007). Further on, physical activity reduces the risk of various kinds of cancer (Moore et al. 2016). Additionally, being engaged into exercising on regular basis plays an important role in stress management (Gibson et al, 2018), general mood and sense of general satisfaction (Weinberg et al, 2019). Physical activity directly influences life quality, most frequently through health. Exercising is a term subjected to physical activity and refers to "physical activity which is planned, structured and repetitive and where the final or intermedial goal is improving or maintaining the level of physical fitness" (Caspersen et al. 1985). Longitudinal researches revealed that exercising decreases the risk of coronary heart diseases, type 2 diabetes, Alzheimer's disease, dementia (Reiner et al. 2013; Rhodes et al. 2017).

In adolescence, exercising influences even the skeleton system and lowers the risk of osteoporosis at an older age by increasing bone mass (Bailey and Martin, 1994), relieves depression, anxiety and stress and increases self-confidence (Calfas and Taylor, 1994). Apparently, sex and age play an important role in behavioural regulation of physical exercising. Butt et al. (2011) report in their study that female adolescents, particularly older ones, are less engaged in physical exercising than male adolescents. Egli et al. (2011) revealed that male students are more motivated by internal factors (e.g. challenge) while female students are more motivated by external factors (e.g. weight management). Despite advantages of regular exercising, it is reduced over the years, especially in adolescence (Dumith et al. 2011; Sanchez-Oliva et al. 2014; van der Horst et al., 2007). A recent meta-analysis revealed this progressive decline in moderate to strong intensity exercising appears even before adolescence, starting in early and middle childhood (Farooq et al., 2020). A recent study (Portela-Pino et al. 2020) proved that boys and girls aged 12-17 had different motives for being engaged into physical exercising (i.e. competition, social acknowledgement, challenge, identity, fun, well-being, muscles, endurance, health, urgent situations in boys, followed by body mass, body image, agility and flexibility in girls), while girls had much more hindrances in being engaged in physical activities than boys (e.g. physical social anxiety, fatigue and indolence). Motivation is a psychic process which stimulates mental or physical activities while affecting our behaviour from the inside. It gives explanation to why people decide to behave in a specific way at a specific moment (Baric, 2012). It is necessary to recognize all the factors, including motivating ones, which are positively connected to the level of physical activity. The purpose of this paper is to establish the

differences between male and female high school students regarding their motivation for physical exercising.

METHODS

Sample of respondents

The sample of respondents includes 240 high school students from Civil Engineering and Geodesy Technical School, and Design, Graphics and Sustainable Civil Engineering School divided by sex in 165 men and 75 women, average age 16.
The students voluntarily filled in the survey.

Sample of variables

Motivation for exercising has been assessed by the Croatian version of survey EMI – 2 (Markland & Ingledew, 1997; Vlasic et al., 2002) consisting of 14 motives: weight management, health avoidance, revitalization, appearance, social recognition, stress management, health, strength and endurance, enjoyment, affiliation, health pressures, competing, nimbleness and challenge.

Description of experimental procedure

Croatian version of EMI-2 has been input into SurveyMonkey electronic application. The link to the survey was distributed among the students with a short explanation of the research. Students filled in the survey by using their mobile phones. It lasted up to 10 minutes.

Data processing methods

For the purpose of this study, we used descriptive statistics where we calculated basic statistic parameters. The differences between male and female students were calculated by Mann-Whitney U test. Statistica ver.14 programme package was used to calculate statistic parameters.

RESULTS AND DISCUSSION

By inspecting table 1, we can see basic descriptive parameters. It is evident that average values are close to maximum values in certain variables. Regarding this is a survey and not abilities assessment, such data were expected. Most of the variables deviate from average normality distribution values which is important for the following statistic processing.

By inspecting results more closely, it is evident that factors POSITIVE HEALTH and STRENGTH AND ENDURANCE deviate to the greatest extent. The stated factors refer to questions assessing subjective feeling of physical activity to health and developing a strong and resistant body, thus the results are expected to come close to maximum values leading on to unbalanced distribution thus it was necessary to apply non-parametric method. Considering the obtained basic statistic parameters, Mann-Whitney U test was used further on to detect differences by sex.

Table 1. Descriptive statistics (N=240)

Variables	***AS± SD***	***MIN/ MAX***	***Skew***	***Kurt***	***K-S***	***max D***
1 Weight Management	*3.33±1.29*	*0.00/5.00*	*-0.37*	*-0.83*	*p < .01*	*0.11*
2 Health Avoidance	*3.34±1.37*	*0.00/5.00*	*-0.80*	*-0.09*	*p < .01*	*0.13*
3 Revitalization	*4.13±0.98*	*0.00/5.00*	*-1.38*	*1.91*	*p < .01*	*0.19*
4 Appearance	*3.56±1.02*	*0.50/5.00*	*-0.83*	*0.39*	*p < .01*	*0.18*

5 Social recognition	*2.29±1.41*	*0.00/5.00*	*0.11*	*-0.87*	*p > .20*	*0.07*
6 Stress Management	*3.23±1.39*	*0.00/5.00*	*-0.68*	*-0.46*	*p < .01*	*0.13*
7 Positive Health	*4.27±0.98*	*0.00/5.00*	*-2.00*	*4.68*	*p < .01*	*0.23*
8 Strength and Endurance	*4.35±0.85*	*0.00/5.00*	*-1.77*	*3.72*	*p < .01*	*0.22*
9 Enjoyment	*3.48±1.32*	*0.00/5.00*	*-0.71*	*-0.34*	*p < .01*	*0.13*
10 Affiliation	*2.27±1.50*	*0.00/5.00*	*0.04*	*-1.10*	*p < .05*	*0.09*
11 Health Pressures	*1.41±1.32*	*0.00/5.00*	*0.84*	*0.03*	*p < .01*	*0.14*
12 Competition	*2.56±1.66*	*0.00/5.00*	*-0.01*	*-1.33*	*p < .05*	*0.10*
13 Nimbleness	*3.67±1.20*	*0.33/5.00*	*-0.83*	*0.10*	*p < .01*	*0.13*
14 Challenge	*3.74±1.10*	*0.25/5.00*	*-0.74*	*-0.10*	*p < .01*	*0.13*

Legend: *AS-arithmetic mean, MIN-minimal result, MAX-maximal result, SD-standard deviation, K-S – Kolmogorov-Smirnova test, MaxD – maximum differences between actual and theoretical cumulative frequencies.*

Table 2 presents arithmetic mean in male and female students. Parameters for Mann-Whitney U test are evident from the obtained results (H and p). Seven out of fourteen factors have statistically significant differences regarding sex. COMPETITION factor differentiates male from female students to the largest extent and it reveals they are motivated for physical activity because they enjoy competitions, consider it entertaining and like winning, which is in accordance with previous studies and knowledge (Portela-Pino et al. 2020). Male students gave higher marks to this motive than female students. It is followed by AFFILIATION factor where exercise motive is considered an opportunity to spend time with their friends and meet new ones. The stated factor is also considered to be a greater motive in male than in female students. WEIGHT MANAGEMENT factor, which refers to the issue that motivation is found in prevention of excess weight and keeping it at a normal level, is a stronger motive in female than male students. This has corroborated researches stating that women give more significance and importance to physical characteristics and the perception of appearance than men (Harter, 1999; Pliner, Chaiken, Flatt, 1990). Additionally, regarding statistical significance, they have bigger motives for exercising when POSITIVE HEALTH factor is considered and which relate to the issues of subjective impact of physical activity to health. REVITALIZATION factor, which refers to a good feeling after exercise, is a stronger motive in female students. STRESS MANAGEMENT factor, which refers to the issue they have a motive for exercising because it helps them to cope with stress and tension more easily, is significantly more appreciated in female students. The last factor with significantly higher marks in female students is HEALTH AVOIDANCE factor where the motive for exercising is prevention of different diseases. The least important motives are health pressures, social recognition and affiliation.

Table 2. Differences in motivation for exercising between male and female high school students

Variables	*AS*		*Z*	*p*
	female (N=165)	*male (N=75)*		
1 Weight Management	*3.48*	*2.97*	*2.78*	*0.01*
2 Health Avoidance	*3.47*	*3.03*	*2.17*	*0.03*
3 Revitalization	*4.23*	*3.88*	*2.59*	*0.01*
4 Appearance	*3.60*	*3.47*	*1.02*	*0.31*
5 Social recognition	*2.19*	*2.50*	*-1.54*	*0.12*
6 Stress	*3.40*	*2.85*	*2.54*	*0.01*
7 Positive Health	*4.35*	*4.09*	*2.58*	*0.01*
8 Strength and endurance	*4.34*	*4.36*	*-0.45*	*0.65*
9 Enjoyment	*3.57*	*3.27*	*1.54*	*0.12*
10 Affiliation	*2.08*	*2.68*	*-2.80*	*0.01*
11 Health pressures	*1.43*	*1.36*	*0.44*	*0.66*
12 Competition	*2.25*	*3.23*	*-4.21*	*0.00*
13 Nimbleness	*3.68*	*3.64*	*-0.03*	*0.98*
14 Challenge	*3.74*	*3.73*	*-0.08*	*0.94*

Legend: *AS-arithmetic mean, Z – Z-test value, p-level of significance*

CONCLUSION

In this research the respondents reveal different kinds of motivation for physical exercising depending on the sex. Observing results on the whole, it is evident that the greatest difference is in factor which we named COMPETITION and it is in favour of male students. Male students evidently like competing more than female students and this is their greatest motivating factor as far as engagement in kinesiological activities is concerned. Competing and competitive spirit has always been a specific and important factor in male sex and it is known for a fact that men are motivated by competition, while women strive to achieve thin figure and are more motivated due to social norms linked to physical appearance. Such a conclusion is stressed even in this research because in female sex REVITALISATION factor followed by POSITIVE HEALTH and STRENGTH AND ENDURANCE factor is particularly the one that has greatest result marks in female students and primarily these factors reveal statistically significant difference compared to male population.

This research confirmed previous knowledge on differences in motivation for exercising between men and women and compelled kinesiologists to continue promoting the importance of physical exercising for health reasons which high school students are well aware of, primarily female population.

REFERENCES

1. Bailey, D. A., & Martin, A. D. (1994). Physical Activity and Skeletal Health in Adolescents. *Pediatric Exercise Science*, *6*(4), 330–347. https://doi.org/10.1123/PES.6.4.330
2. Baric, R. (2012). Motivacija i prepreke za tjelesno vježbanje. *Arh Hig Rada Toksikol*, *63*, 47–58.
3. Bauman, A. E., Sallis, J. F., Dzewaltowski, D. A., & Owen, N. (2002). Toward a better understanding of the influences on physical activity: The role of determinants, correlates, causal variables, mediators, moderators, and confounders. *American Journal of Preventive Medicine*, *23*(2 SUPPL. 1), 5–14. https://doi.org/10.1016/S0749-3797(02)00469-5
4. Butt, J., Weinberg, R. S., Breckon, J. D., & Claytor, R. P. (2011). Adolescent Physical Activity Participation and Motivational Determinants Across Gender, Age, and Race. *Journal of Physical Activity and Health*, *8*(8), 1074–1083. https://doi.org/10.1123/JPAH.8.8.1074
5. Calfas, K. J., & Taylor, W. C. (1994). Effects of Physical Activity on Psychological Variables in Adolescents. *Pediatric Exercise Science*, *6*(4), 406–423. https://doi.org/10.1123/PES.6.4.406
6. Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. Public health reports, 100(2), 126.
7. Chen, J., & Millar, W. J. (2001). Starting and sustaining physical activity. Health Reports, 12(4), 33-43.
8. Conroy, M. B., Cook, N. R., Manson, J. E., Buring, J. E., & Lee, I. M. (2005). Past physical activity, current physical activity, and risk of coronary heart disease. *Medicine and Science in Sports and Exercise*, *37*(8), 1251–1256. https://doi.org/10.1249/01.MSS.0000174882.60971.7F
9. Dumith, S. C., Gigante, D. P., Domingues, M. R., & Kohl, H. W. (2011). Physical activity change during adolescence: a systematic review and a pooled analysis. *International Journal of Epidemiology*, *40*(3), 685–698. https://doi.org/10.1093/IJE/DYQ272
10. Egli, T., Bland, H. W., Melton, B. F., & Czech, D. R. (2011). Effects of sex, race, and age on college students' exercise motivation of physical activity. Journal of American college health, 59(5), 399. https://doi.org/10.1080/07448481.2010.513074
11. Fakhouri, T. H. I., Hughes, J. P., Burt, V. L., Song, M., Fulton, J. E., & Ogden, C. L. (2012). *Physical Activity in U.S. Youth Aged 12-15 Years, 2012 Key findings Data from the combined National Health and Nutrition Examination Survey (NHANES) and the NHANES National Youth Fitness Survey, 2012*. http://www.cdc.gov/nchs/data/databriefs/db141_table.pdf#3.
12. Farooq, A., Martin, A., Janssen, X., Wilson, M. G., Gibson, A. M., Hughes, A., & Reilly, J. J. (2020). Longitudinal changes in moderate-to-vigorous-intensity physical activity in

children and adolescents: A systematic review and meta-analysis. *Obesity Reviews*, *21*(1), e12953. https://doi.org/10.1111/OBR.12953

13. Harter, S. (1999). Symbolic interactionism revisited: Potential liabilities for the self constructed in the crucible of interpersonal relationships. *Merrill-Palmer Quarterly (1982-)*, 677-703.
14. Markland, D., & Ingledew, D. K. (1997). The measurement of exercise motives: Factorial validity and invariance across gender of a revised Exercise Motivations Inventory. *British Journal of Health Psychology*, *2*(4), 361–376. https://doi.org/10.1111/J.2044-8287.1997.TB00549.X
15. Mišigoj-Duraković, M., Duraković, Z., Findak, V., Heimer, S., Horga, S., & Latin, V. (2018). Tjelesno vježbanje i zdravlje. Znanje.
16. Moore, S. C., Lee, I. M., Weiderpass, E., Campbell, P. T., Sampson, J. N., Kitahara, C. M., Keadle, S. K., Arem, H., de Gonzalez, A. B., Hartge, P., Adami, H. O., Blair, C. K., Borch, K. B., Boyd, E., Check, D. P., Fournier, A., Freedman, N. D., Gunter, M., Johannson, M., … Patel, A. v. (2016). Association of leisure-time physical activity with risk of 26 types of cancer in 1.44 million adults. *JAMA Internal Medicine*, *176*(6), 816–825. https://doi.org/10.1001/jamainternmed.2016.1548
17. Pliner, P., Chaiken, S., & Flett, G. L. (1990). Gender differences in concern with body weight and physical appearance over the life span. *Personality and social psychology bulletin*, *16*(2), 263-273.
18. Portela-Pino, I., López-Castedo, A., Martínez-Patiño, M. J., Valverde-Esteve, T., & Domínguez-Alonso, J. (2020). Gender differences in motivation and barriers for the practice of physical exercise in adolescence. *International Journal of Environmental Research and Public Health*, *17*(1). https://doi.org/10.3390/ijerph17010168
19. Reiner, M., Niermann, C., Jekauc, D., & Woll, A. (2013). *Long-term health benefits of physical activity-a systematic review of longitudinal studies*. https://doi.org/10.1186/1471-2458-13-813
20. Rhodes, R., Janssen, I., Bredin, S. S., & Warburton, D. (2017). *Article in Psychology and Health*. https://doi.org/10.1080/08870446.2017.1325486
21. Sanchez-Oliva, D., Sanchez-Miguel, P. A., Leo, F. M., Kinnafick, F. E., & García-Calvo, T. (2014). Physical Education Lessons and Physical Activity Intentions Within Spanish Secondary Schools: A Self-Determination Perspective. *Journal of Teaching in Physical Education*, *33*(2), 232–249. https://doi.org/10.1123/JTPE.2013-0043
22. Stuart, J. H. B., & Nanette, M. (2007). Psychology of physical activity: Determinants, well-being and interventions. *Psychology of Physical Activity: Determinants, Well-Being and Interventions*, 1–428. https://doi.org/10.4324/9780203019320/PSYCHOLOGY-PHYSICAL-ACTIVITY-STUART-BIDDLE-NANETTE-MUTRIE
23. van der Horst, K., Paw, M. J. C. A., Twisk, J. W. R., & van Mechelen, W. (2007). A brief review on correlates of physical activity and sedentariness in youth. *Medicine and Science in Sports and Exercise*, *39*(8), 1241–1250. https://doi.org/10.1249/MSS.0B013E318059BF35

24. Vlasic, J., Baric, R., Oreb, G., & Kasovic, M. (2002). Exercise motives in middle aged and eldery female population. In Proceedings of the 3rd international scientific conference Kinesiology-new perspectives (pp. 462-766).
25. Weinberg, R. S., & Gould, D. (2023). Foundations of sport and exercise psychology. Human kinetics.

Differences in The Motivation for Exercise of Wheelchair Basketball Players After Spinal Injury

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ABSTRACT

Spinal cord injury is a destructive neurological and pathological condition that causes major motor, sensory and autonomic dysfunctions. Due to limitations in mobility, medical aids, accessibility, and socioeconomic status, the ability to participate in physical activities or sporting events is significantly impaired. A variety of adaptive sports provides opportunities for all people, including those with spinal cord injuries, to experience the positive effects of physical activity. One of the most popular Paralympic sports is wheelchair basketball with growing popularity and international competitions around the world. The aim of this work was to determine the motivational structure of wheelchair basketball players after spinal injury and to investigate the difference in motivation in relation to gender. The sample of this study consisted of individuals with traumatic spinal injuries who play basketball in a wheelchair. These are: weight management, health avoidance, revitalization, appearance, social recognition, stress management, health, strength and endurance, enjoyment, affiliation, health pressures, competing, nimbleness and challenge. The Croatian version of the EMI-2 questionnaire, which contains fourteen motivations for exercise, was used to assess motivation for exercise. The results of this study show that the motivation of the respondents is of medium intensity and that the motivation of women and men differs significantly in 4 motives. Sport in a wheelchair is also a form of rehabilitation due to the feeling of belonging to the community and shortening of the time spent in different rehabilitation facilities.

Keywords: paralympic sports, physical exercise, EMI-2, rehabilitation

INTRODUCTION

Spinal cord injury is a destructive neurological and pathological condition that causes major motor, sensory and autonomic dysfunction. The pathophysiology itself includes acute and chronic phases and involves a series of destructive events such as ischemia, oxidative stress, inflammation and musculoskeletal dysfunction (Alizadeh, Dyck & Karimi-Abdolrezaee, 2019).

Worldwide, the annual incidence of spinal cord injury ranges from 10.4 to 83 cases per million population, placing a heavy burden on the health care system (Wyndaele & Wyndaele, 2006). In Europe, the incidence of spinal cord injury ranges from 16 to 19.4 new cases per million population per year, and this incidence is similar in other European countries. Comparing data from Europe and the rest of the world, spinal cord injuries caused by falls are the most common one in Europe (Cripps et al.,

2011). Throughout centuries, spinal cord injuries have been associated with high mortality, sometimes immediately, sometimes after a period of pain and inadequate conditions for the patient with limited mobility. Since the second half of the 20th century, the approach to spinal cord injury rehabilitation has changed, resulting in increased survival rates and improved quality in patients' functional activities of daily living (Schnurrer et al., 2012). Spinal cord injuries significantly affect a person's functional ability to participate in physical activities or sporting events due to limitations in mobility, medical aids, accessibility and socioeconomic status. However, the benefits of cardiovascular and other exercise are well established in both physically active individuals and those with disabilities. Although spinal cord injury is associated with the quality of life, poor health, economic and social outcomes, these outcomes are primarily related to environmental and physical activity (Rayes et al., 2020).

The latest research on sports for individuals with spinal injuries highlights various advantages of physical exercise. It helps improve strength and balance, maintain healthy body weight, enhance transfer and daily life functions. Furthermore, it has been found to help alleviate acute and chronic health issues, prevent obesity and improve lung function (Ekelman et al., 2017). Research has revealed that engaging in sports is beneficial for individuals with disabilities, offering a range of positive effects such as increased self-efficacy, self-confidence, freedom, and motivation. These psychosocial advantages are commonly linked to intrinsic and extrinsic motivation, despite differences in study design, participant backgrounds and sport types. It has been proofed that sports have positive effects in regulating mood and reducing stress not just for recreational purposes (Rayes et al., 2020). Among Paralympic sports, wheelchair basketball has gained significant popularity, with international competitions held worldwide. As interest and professionalism in this sport continue to grow, there has been a growing need for a more scientific perspective (Ferreira da Silva et al., 2022). The aim of this research is to determine the motivational structure for exercise among basketball players in wheelchairs after a spinal injury, and to examine differences in motivation for exercise based on gender. The results obtained from this study should help in understanding the motivation of people with chronic spinal traumatic injury.

METHODS

Sample of variables

This study examines the impact of wheelchair basketball on individuals who have suffered traumatic spinal injuries. The group of participants consists of 10 women and 10 men, aged between 18 and 54, with an average age of 27.3. To be eligible for the research, participants must receive training for two hours twice a week and must be a member of a wheelchair basketball club under the supervision of a coach. The primary inclusion criterion is a diagnosis of traumatic spinal injury and a minimum of three months of training. Exclusion criteria include acute patients who are unable to follow instructions and complete the questionnaire on a mobile device. Before being invited to participate, participants were contacted by phone and informed of the study's purpose and potential risks. The study adhered to ethical guidelines, participation was voluntary and anonymous and

participants were free to withdraw from the study at any time.

Measuring instrument

The Croatian version of the EMI-2 questionnaire was entered into the SurveyMonkey electronic application. The Croatian version of the EMI-2 questionnaire was used to assess motivation for exercise (Vlasic et al., 2002; Markland & Hardy, 1993). The EMI-2 questionnaire is often used to assess motivation to exercise because of its high reliability (Kim & Cho, 2020). The reliabilities of the internal consistency (Cronbach α) of the subscales obtained in the research are satisfactory and range from 0.70 to 0.90 (Anic et al., 2021). The questionnaire contains 51 items representing 14 possible motivations for exercise. These are: weight management, health avoidance, revitalization, appearance, social recognition, stress management, health, strength and endurance, enjoyment, affiliation, health pressures, competing, nimbleness and challenge. For example, some of the questions are: *„Personally, I exercise (or might exercise) ... To stay slim "; ...To avoid ill-health, ...Because it makes me feel good.* Items are formulated to answer the question of why a person exercises or would exercise, with responses marked on a Likert scale (0- not at all true for me, 5- very true for me). The questionnaire was distributed to the participants along with a brief explanation of the research and brief instructions on how to complete the questionnaire.

Procedure

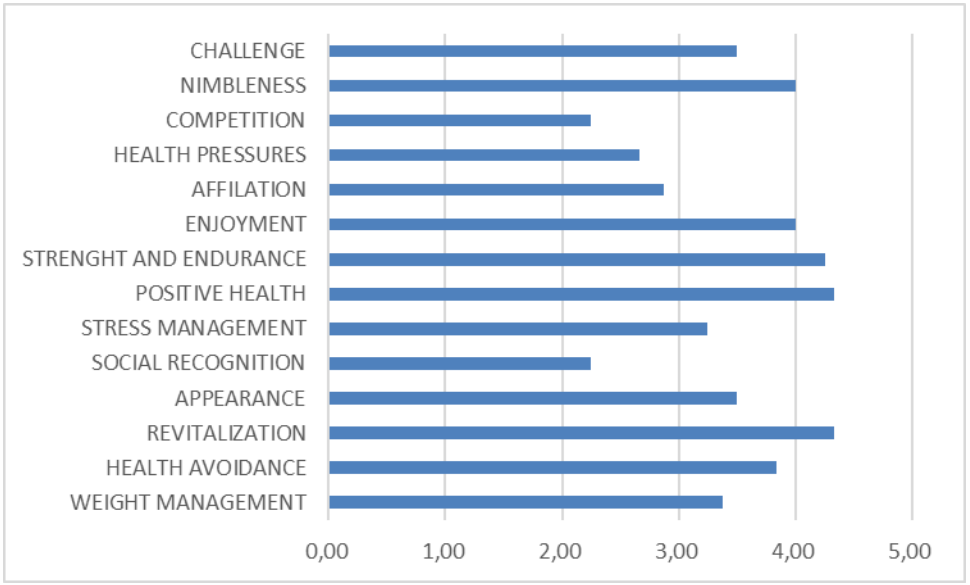
Data of motivation for physical exercise were collected through the online EMI-2 questionnaire. Participants were asked not to participate in training or other heavy physical activities on the day of filling out the questionnaire.

RESULTS AND DISCUSSION

In this paper, the representation of motives for practicing of all the wheelchair basketball players was analyzed, followed by the one in regard to the participants' gender. Descriptive parameters were also calculated. Motivation for exercise of all the participants together was presented graphicaly (Figure 1).

The obtained results show that competition and social pressure are the least important motives for practicing basketball players in wheelchairs. Positive health, revitalization, strength and endurance were cited as the most important motives for exercissing.

Figure 1. *Graphic representation of motivations for exercise of all participants (N-20)*



The motivational structure with regard to gender is shown in Figure 2. Women give the most importance to 'Appearance motives', but very high frequencies were also obtained for 'Weight management'. Women attach the least importance to motives of 'Social recognition'. Men cite 'Revitalization and Nimbleness' as the most important motivations for exercise. 'Appearance and Social recognition' were rated as the least important motives. It can be seen that the biggest difference between male and female participants is in the motive of 'Social recognition, Affiliation, Health Pressures and Competition' and the most similar assessments were given for the motive of 'Strength and endurance and Stress management'.

Figure 2. *Motivational structure of wheelchair basketball players with regard to gender*

Table 1. *Descriptive parameters and differences in the structure of motives for exercise with regard to gender*

Variables	*MEDIAN M*	*SD M*	*MEDIAN W*	*SD W*	*U*	*Z*	*p-value*
1 Weight Management	*3,25*	*1,35*	*4,13*	*1,25*	*30*	*-1,47*	*0,14*
2 Health Avoidance	*4,33*	*1,48*	*3,33*	*0,99*	*34,5*	*1,13*	*0,26*
3 Revitalization	*4,50*	*1,46*	*4,00*	*0,66*	*35*	*1,10*	*0,27*
4 Appearance	*3,13*	*1,29*	*4,25*	*1,16*	*32*	*-1,32*	*0,19*
5 Social recognition	*3,13*	*1,25*	*1,25*	*1,11*	*15*	*2,61*	*0,01*
6 Stress Management	*3,25*	*1,28*	*3,25*	*0,60*	*44,5*	*-0,38*	*0,71*
7 Positive Health	*4,33*	*1,42*	*4,00*	*0,96*	*44*	*0,42*	*0,68*
8 Strength and Endurance	*4,25*	*1,34*	*4,00*	*1,29*	*45,5*	*0,30*	*0,76*
9 Enjoyment	*4,00*	*1,33*	*3,88*	*0,98*	*42*	*0,57*	*0,57*
10 Affiliation	*3,88*	*1,31*	*2,00*	*0,92*	*16,5*	*2,49*	*0,01*
11 Health Pressures	*3,33*	*1,22*	*1,50*	*0,90*	*10*	*2,99*	*0,00*
12 Competition	*3,88*	*1,37*	*1,50*	*0,82*	*9,5*	*3,02*	*0,00*
13 Nimbleness	*4,33*	*1,48*	*3,67*	*0,62*	*41*	*0,64*	*0,52*
14 Challenge	*3,75*	*1,36*	*3,50*	*0,61*	*42,5*	*0,53*	*0,60*

Legend: *SD-standard deviation, U-U-test value, Z – Z-test value, p-level of significance*

Data analysis tested differences in the motivational structure of wheelchair basketball players with regard to gender (Table 1). Descriptive parameters show that in this sample of participants, regardless of gender, it is possible to observe mostly relatively average scores in all dimensions. Based on the analysis, statistically significant differences in the motives for exercising between men and women were determined on the dimensions of 'Social recognition, Affiliation, Health Pressures and Competition', always in favor of men.

Poor hygiene during self-catheterization, which must be performed at least four to five times a day in persons with a spinal injury, is associated with the frequent occurrence of urinary infections. A clinical study that analyzed the effects of basketball in a wheelchair over 12 months, proved the prevalence of *Escherichia coli* in the urine strips of the participants. In addition to the above, there was a reduction in urinary tract infections, an improvement in biochemical and immune biomarkers assessed by practicing basketball in a wheelchair (Cavalcante et al., 2022).

Despite many positive aspects and scientifically proven effects of exercise on physical and mental health, as well as numerous campaigns, programs and targeted interventions to keep as many people active as possible, in industrialized countries there is an evident decline in physical activity as a function of age (Phongsavan et al., 2007).

Study limits

The acute stages of spinal injury are associated with greater potential for brain recovery and plasticity compared with the chronic stage and thus may involve greater motivation for

physical activity (Ding et al., 2005). Research should also be able to determine the applicability of wheelchair basketball according to injury severity and comorbidities, as well as the duration of the effect of wheelchair training (short-term and long-term effects). For this type of research, it would be interesting to include participants in other wheelchair sports, such as tennis, which may be the subject of future studies comparing motivation and functional recovery of acute and chronic patients after traumatic spinal cord injury.

Nonetheless, the consistency of these findings underscores the need for further research on the cause-effect relationships between motivation and quality of life using a longitudinal research methodology and incorporating qualitative methods. The results cannot be generalized to all age groups because this study used a small sample of participants.

CONCLUSION

Due to various loads on the musculoskeletal system, wheelchair basketball is an extremely important sport after acute rehabilitation since it reduces the number of injuries and shortens the recovery time after a spinal injury. In order for the process of prevention or rehabilitation to be as successful as possible, a detailed assessment of motivation with reliable and sensitive motivation tests is needed.

'Health, Nimbleness and Strength and endurance' are the strongest motivations for wheelchair basketball players to exercise. For women, the most important motive is 'Appearance', as well as 'Weight control', while for men it is 'Revitalization and Nimbleness'. The statistically significant difference in motivation between male and female basketball players is evident the most in 'Social recognition, Affiliation, Health Pressures and Competition' motives (in favor of men).

This research can be used to plan support programs for those with spinal injuries, educate families and raise public awareness.

REFERENCES

1. Alizadeh, A., Dyck, S.M. & Karimi-Abdolrezaee, S. (2019). Traumatic Spinal Cord Injury: An Overview of Pathophysiology, Models and Acute Injury Mechanisms. *Frontieres in Neurology*, *10*(282), 1-25. https://doi.org/10.3389/fneur.2019.00282
2. Anic, P., Host, I. & Mohoric, T. (2021). Provjera konstruktne i kriterijske valjanosti Skale situacijske motivacije u sportskom kontekstu. *Suvremena psihologija, 24*, 27-43. http://suvremena.nakladaslap.com/public/pdf/24-1-3.pdf
3. Cavalcante, R.,N., Santos, A.,C.,S., Rodrigues, R.,A.,S., Napoleão, A.,C.,B., Balogun, S.,O., Andrade, B.,R.,M., Fett, C.,A., Zavala, A.,A.,Z., Arunachalam, K., & Oliveira, R.,G. (2022). Wheelchair basketball improves the treatment of urinary tract infection in people with motor disabilities: a clinical trial. *Rev Assoc Med Bras (1992)*, *68*(5), 559-567. https://doi.org/10.1590/1806-9282.20210896

4. Cripps, R.A., Lee, B.B., Wing, P., Weerts, E., Mackay, J. & Brown, D. (2011). A global map for traumatic spinal cord injury epidemiology: towards a living data repository for injury prevention. *Spinal Cord, 49*(4), 493–501. https://doi.org/10.1038/sc.2010.146
5. Ding, Y., Kastin, A.J. & Pan, W. (2005). Neural plasticity after spinal cord injury. *Curr Pharm Des*.;*11*(11), 1441-1450. https://doi.org/10.2174%2F1381612053507855
6. Ekelman, B.A., Allison, D.L., Duvnjak, D., DiMarino, D.R., Jodzio, J. & Iannarelli, P.V. (2017). A wellness program for men with spinal cord injury: participation and meaning. *Occupational Therapy Journal of Research*, *37*(1), 30-9. https://doi.org/10.1177/1539449216672170
7. Ferreira da Silva, C.M.A., de Sá, K.S.G., Bauermann, A., Borges, M., de Castro Amorim, M., Rossato, M., Gorla, J.I., & de Athayde Costa e Silva, A. (2022). Wheelchair skill tests in wheelchair Basketball: A systematic review. *PLoS ONE*, *17*(12). https://doi.org/10.1371/journal.pone.0276946
8. Kim, S., & Cho, D. (2020). Validation of exercise motivations inventory – 2 (EMI-2) scale for college students. *Journal of American College Health 70*, 1-8. http://dx.doi.org/10.1080/07448481.2020.1726929
9. Markland, D., & Hardy, L. (1993). The Exercise Motivations Inventory: Preliminary development and validity of a measure of individuals' reasons for participation in regular physical exercise. *Personality and Individual Differences, 15*(3), 289–296. https://doi.org/10.1016/0191-8869(93)90219-S
10. Phongsavan, P., McLean, G. & Bauman, A. (2007) Gender differences in influences of perceived enviromental andpsychosocial correlates on recommended level of physical activity among New Zealanders. *Psychol Sport Exerc 8,* 939-950. http://dx.doi.org/10.1016/j.psychsport.2006.11.004
11. Rayes, R., Ball, C., Lee, K. & White C. (2020). Adaptive Sports in Spinal Cord Injury: a Systematic Review. *Current Physical Medicine and Rehabilitation Reports 10,* 145–153. https://doi.org/10.1007/s40141-022-00358-3
12. Vlasic, J., Baric, R., Oreb, G. & Kasovic, M. (2002). Exercise motives in middle aged and eldery female population. U: D. Milanovic & F. Prot (Ur.). Proceedings of the 3rd international scientific conference: Kinesiology - new perspectives (str. 462–466). Zagreb: Faculty of kinesiology
13. Wyndaele, M. & Wyndaele, J.J. (2006). Incidence, prevalence and epidemiology of spinal cord injury: what learns a worldwide literature survey? *Spinal Cord*, *44*(9), 523-29. https://doi.org/10.1038/sj.sc.3101893

Comparison Between Croatian Sambo Representatives' and Recreational Soccer Players' Exercise Addiction

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ABSTRACT

Physical activity has a positive impact on mental health and is used for the prevention and treatment of some addictions. However, excessive physical activity can lead to overtraining, development of pathological patterns, and even exercise addiction. Athletes are at a higher risk of developing exercise addiction. Those who suffer from exercise addiction display a pathological pattern of behavior that can result in negative psychological consequences and significantly impact their lives. This study aimed to determine the prevalence of exercise addiction symptoms in the Croatian SAMBO national team and compare it with recreational soccer players. In this study, the Croatian version of the „Exercise Addiction Inventory "(EAI) questionnaire was used. The questionnaire contains 6 statements with which we examine whether the participants have behavioral patterns that are indicative of exercise addiction. The results showed that 6% of the sampled sambo athletes are exercise addicts, 88% exhibit addiction symptoms, and 6% showed no signs of addiction. The study also found no significant difference between sambo athletes and recreational soccer players.

Keywords: EAI; Disorder; Physical activity; Quality of life; Training

INTRODUCTION

SAMBO is originally a Russian martial art; the abbreviation translates directly as "self-defence without weapons". It was developed for the needs of the Soviet military and police. It can be described as a combination of judo, freestyle wrestling and jiu-jica with traditional aspects of Caucasian and Siberian peoples. After the USSR's collapse, it became increasingly popular and today has more than 100 national federations within the world federation, FIAS (Fédération Internationale de Sambo). We divide SAMBO into sports and combat SAMBO, the main difference being that in combat, in addition to throwing and leverage techniques, choke holds and punches to various parts of the body are allowed, and more protective equipment is used. The Croatian federation SAMBO was founded in 2010 and has twelve registered clubs. It is a Zagreb City Sports Association member and the Croatian Olympic Committee. The Croatian national team members regularly win medals at major international competitions, and the Croatian SAMBO can boast of being world and European champions and having won gold at the European Games ("About Sport"). Croatian sambo national team members train hard every day, preparing for competitions of different levels, national, European and world championships, etc.

The positive effects of physical activity on mental health are well known. Reducing stress, anxiety and depression contributes to psychological well-being and quality of life (Dunn, Trivedi & O'Neal, 2001). There is a link between physical activity and better cognition, i.e., better memory. The mechanism is not yet fully understood, but physical activity appears to be associated with increased expression of neurotrophic factors in some areas of the brain (Vina et al., 2012). Sport and physical activity play an important role in the prevention of some addictions and are used as therapy for drug and alcohol addiction (Vizintin & Baric, 2013). All these are positive psychological consequences of physical activity, but there is also another side of the coin. Too frequent and too intense physical activity can lead to overtraining, the development of pathological patterns of exercise and even exercise addiction. Addiction can be defined as a disorder that implies the repetition of actions characterized by psychological processes and behaviors that involve the compulsion to use addictive substances on a regular basis, in this case, it involves physical activity with the aim of experiencing pleasure or avoiding discomfort. Exercise addicts suffer withdrawal-like symptoms when they stop or take a break from exercise, suggesting that this phenomenon is very real and serious. The prevalence of exercise addiction in the general population is approximately 7% (Vizintin & Baric, 2013). There is a higher risk of developing exercise addiction among endurance athletes (14.2%), followed by ball sports (10.4%), exercisers in gyms (8.2%) and athletes from strength disciplines, where belong and sambists, who have a slightly lower risk of developing addiction (6.4%) (Di Lodovico, Poulnais, & Gorwood, 2019). Exercise addiction is psychophysical in nature, and addicts themselves lose the benefits of moderate, regular exercise. One of the main characteristics of addicts is that they do not control the activity, but the activity controls them. Therefore, they continue to exercise even when they are injured or sick, regardless of the pain (Bungic & Baric, 2009).

Vizitin and Baric (2013) researched a sample of 120 Croatian exercisers to determine symptoms of addiction and gender differences among exercisers. They conclude that 9.1% of exercisers belong to the category of addicts, 84.3% show some symptoms, while 6.6% show no symptoms of addiction. There are more men among addicts, while there are more women in the at-risk group and among those without symptoms. Compared to women, men more often increase the amount of training and have conflicts with the environment due to the amount of training. In addition, men are more likely to take supplements, which in itself has been associated with the occurrence of addiction symptoms. On the other hand, Lindwall and Palmeira (2009), based on a sample of Swedish and Portuguese male and female exercisers, did not find statistically significant differences by gender (Lindwall & Palmeira, 2009). Lichtenstein et al. (2014) examine differences in the prevalence of exercise dependence in team and individual sports, comparing soccer players and people involved in fitness (Lichtenstein et al., 2014). They find that there is no statistically significant difference between the groups (7.1% in the football group and 9.7% in the fitness group). Baf (2021) examines a sample of 195 recreational exercisers and 39 professional athletes and concludes that 6% of exercisers belong to the risk group for developing addiction, 80% belong to the group with certain

symptoms of exercise addiction, and 14% of exercisers are without addiction symptoms. According to the results of the same study, competitive athletes show more symptoms than unregistered recreational athletes, but no differences in addiction symptoms were found in relation to the type of sport (Baf, 2021).

Exercise addiction can have negative psychological consequences such as frustration, irritability, tension, aggressiveness and guilt. In any case, a person should seek professional psychological help and reduce, adjust, and in some cases even temporarily stop exercising (Bungic & Baric, 2009). Kinesiologists and trainers have a great responsibility here, because they have to educate the exercisers and, in some cases, even reject a person who does not want to adapt and reduce training, and shows symptoms of sports addiction.

Perfectionist athletes are among the risk groups for developing exercise addiction (Vina et al., 2012). In the medical classification of diseases, exercise addiction is not officially classified, but excessive exercise falls under the symptoms of eating disorders (Vizintin & Baric, 2013).

When we talk about athletes, it is important to mention the phenomenon of overtraining. Athletes who are addicted to exercise can easily get into a state of overtraining. It manifests itself in a poor psychophysical condition of athletes caused by excessive demands and too high intensity of sports training. Overtraining manifests itself through mechanical, metabolic and psychological stress (Tremblay, Inman & Willms, 2000). When we speak of psychological stress, we mean mood disturbances, emotional instability and decreased motivation. Changes in the athlete's mood can be a good indicator of excessive training intensity and volume, and show the need to adjust the program and relieve the athlete. Overtrained athletes are often sick, suffer from weakened immunity, and all this is caused by excessive exercise (Bungic & Baric, 2009). Exercise addiction is becoming an increasingly interesting subject of research. However, there is not a large amount of research on this topic in Croatia, especially among the sports population. Therefore, the goal of this research is to study the occurrence of exercise addiction in a sample of Croatian SAMBO national team players and compare them with recreational soccer players. According to Di Lodovico et al. (2019) football players have a slightly higher risk of developing exercise addiction, compared to athletes from strength sports (including SAMBO). However, the higher competitive rank of the examined samba players indicates that there could be more exercise addicts in that group compared to recreational soccer players (Baf, 2021).

The main goal of this paper is to determine the prevalence of symptoms of exercise addiction in a sample of Croatian SAMBO national team competitors, and to compare them with a sample of recreational soccer players.

METHODS

Measurement procedure

The Croatian version of the "Exercise Addiction Inventory" (EAI) (Terry, Szabo & Griffiths, 2004; Vižintin & Barić, 2013) was entered into the *SurveyMonkey* electronic application. The participants received a link with brief instructions to complete the survey on their mobile devices, which takes approximately 5 minutes.

Consent was obtained from all participants before the study. Completing the questionnaire was voluntary and anonymous, and participants could withdraw at any time.

Sample of respondents

The selected group comprises 17 skilled adult athletes hailing from three prominent Sambo clubs: SAMBO club Ban, SAMBO club Crows, and SAMBO club Zag. They serve as the mainstay of the Croatian SAMBO national team and consistently vie at national and international levels. In addition, we gathered a sample of 12 soccer players from the Faculty of Kinesiology in Zagreb, who are active students engaging in recreational football or competing at lower tiers like county and regional levels. The average age of all participants stands at 22.54 (standard deviation=3.64).

Measuring instrument

The Croatian version of the "Exercise Addiction Inventory" (EAI) (Terry, Szabo & Griffiths, 2004; Vizintin & Baric, 2013) was used for this research. The questionnaire contains 6 statements with which we examine whether the participants have behavioral patterns that are indicative of exercise addiction. When filling in, the participant assesses how much they agree with a certain statement, on a five-point Likert scale (1 – Strongly disagree, 2 - Disagree, 3 - Neither agree nor disagree, 4 - Agree, 5 - Strongly Agree'), and some of the statements read*: ''Exercise is the most important thing in my life'', ''Conflicts have arisen between me and my family and/or my partner about the amount of exercise I do'', ''I use exercise as a way of changing my mood ''*. The final result is obtained by summing the points, the threshold value is 15% of the highest values of the total result. For all participants who achieve a value of 24 or more, we can say that they are addicted to exercise, participants with a score in the range of 13 to 23 points have some symptoms, while those with 12 or less do not show symptoms of addiction (Terry et al., 2004).

Sample of variables

The dimensions of the questionnaire and the sport played were the variables analyzed in this study.

Data processing methods

In this study, we utilized the Statistic aver.14 software to calculate statistical parameters. We used descriptive statistics to determine the percentage of participants who did not have addiction symptoms, those who had some symptoms, and those who were at risk of exercise addiction. We checked the normality of the distribution of dependence in both groups using the Shapiro-Wilk test, and then compared the two groups using Student's t-test.

RESULTS AND DISCUSSION

According to the findings, 6% of the sampled sambo athletes are exercise addicts, while 88% display some symptoms of addiction. Additionally, 6% of the sambo athletes showed no signs of exercise addiction. All soccer players were found to exhibit certain symptoms of addiction. The t-test results indicated that there is no statistically significant difference between the two groups ($t = -0.07$ ($df = 27$); $p = .95$).

	M (arithmetic mean)	*SD (standard deviation)*
Soccer	*19.25*	*2.83*
Sambo	*19.34*	*3.90*

***Table 1**. Descriptive data*

Based on the fact that SAMBO is categorized as a strength sport, the study's findings are consistent with previous research. Specifically, it shows that SAMBO athletes have a slightly lower risk of developing exercise addiction than athletes who engage in endurance sports (14.2%), ball sports (10.4%) and individuals who exercise in fitness centers (8.2%) (Di Lodovico et al., 2019).

Most sambists belong to the group that shows certain symptoms of addiction. Although we cannot classify them as exercise addicts, we can see them as a risk group for the development of exercise addiction. It is well known that exercise addiction and eating disorders are linked. The constant need for mass regulation due to weight classes puts martial arts athletes at risk of developing eating disorders (Taheri, 2017). People with eating disorders often exercise compulsively, using it as a means to compensate for caloric intake (Harris et al., 2022). The perfectionist efforts of the athlete himself and the imperative to achieve top sports results can also be factors that could push people with certain symptoms to develop an addiction to exercise. Therefore, coaches, sports psychologists and others who participate in the training process should be aware of the symptoms of addiction, implement preventive strategies and provide help to addicted athletes.

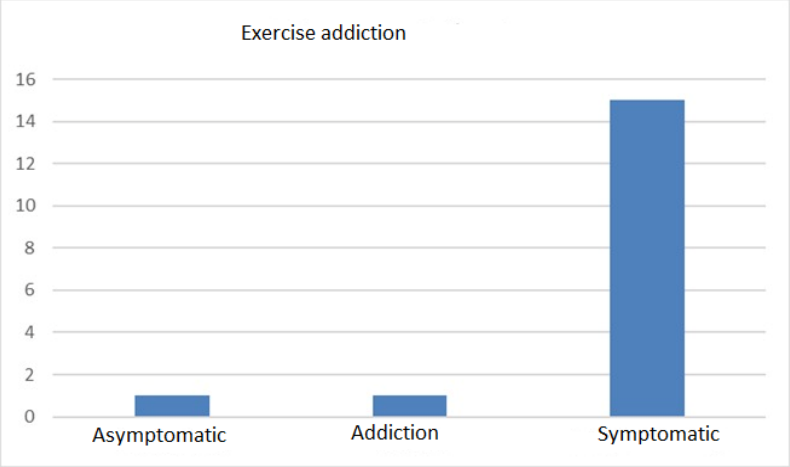

***Figure 1.** Graph of exercise dependence in sambo athletes*

All recreational soccer players belong to a group that shows certain symptoms of addiction, they can also be seen as a risk group for the development of exercise addiction. All of them are kinesiology students, which means that they must be prepared for significant physical loads as part of the classes themselves, and because of belonging to this specific student population, they are more likely to develop addiction (Szabo & Griffiths, 2007).

CONCLUSION

The positive aspects of physical activity are well known. On the other hand, excessive and too intense training can have negative physical and psychological consequences and lead to exercise addiction. Sambist competitors, like other athletes, train hard every day to achieve peak athletic performance and very often have

to regulate their body mass for weight class categories. The results of this study show that 6% of sambo athletes from this sample belong to the category of exercise addicts, 88% show certain symptoms, while 6% of sambo athletes do not show symptoms of exercise addiction. There is no statistically significant difference between sambo athletes and recreational soccer players, despite the difference in rank and sport. Most of the total sample shows certain addiction symptoms, and we can consider them all as a risk group for developing exercise addiction. The focus should be on raising awareness and prevention of the phenomenon of addiction, and this process should involve all those involved in the educational process. In the future, further research should be conducted to clarify what factors influence the development of symptoms and to compare male and female athletes from different sports.

RESEARCH LIMITATIONS AND SCIENTIFIC CONTRIBUTION

The sample of respondents is relatively small, which could be the reason why no statistically significant difference was found between the groups. Also, only two sports were compared; it would be good if athletes from endurance sports (and not only athletes from strength and ball sports) were included. Nevertheless, the above data may help coaches, sports psychologists, and other professionals in the prevention, detection, and treatment of symptoms of exercise addiction.

REFERENCES

1. Baf, V. (2021). *Uloga perfekcionizma, socijalne anksioznosti zbog izgleda i vrste tjelesne aktivnosti u objašnjenju simptoma primarne ovisnosti o vježbanju* (Doctoral dissertation, University of Rijeka. Faculty of Humanities and Social Sciences. Department of Psychology).
2. Bungic, M. & Baric, R. (2009). Tjelesno vježbanje i neki aspekti psihološkog zdravlja. *Hrvatski športskomedicinski vjesnik*, *24*(2), 65-75.
3. Di Lodovico, L., Poulnais, S., & Gorwood, P. (2019). Which sports are more at risk of physical exercise addiction: A systematic review. *Addictive behaviors*, *93*, 257-262. https://doi.org/10.1016/j.addbeh.2018.12.030
4. Dunn, A. L., Trivedi, M. H. & O'Neal, H. A. (2001). Physical activity dose-response effects on outcomes of depression and anxiety. *Database of Abstracts of Reviews of Effects (DARE): Quality-assessed Reviews*.
5. Harris, A., Aouad, P., Noetel, M., Hay, P. & Touyz, S. (2022). Measuring exercise in eating disorder patients: a Delphi study to aggregate clinical and research knowledge. *Journal of Eating Disorders*, *10*(1), 139.
6. Lichtenstein, M. B., Larsen, K. S., Christiansen, E., Støving, R. K. & Bredahl, T. V. G. (2014). Exercise addiction in team sport and individual sport: Prevalences and validation of the exercise addiction inventory. *Addiction Research & Theory*, *22*(5), 431-437 https://doi.org/10.3109/16066359.2013.875537

7. Lindwall, M. & Palmeira, A. (2009). Factorial validity and invariance testing of the Exercise Dependence Scale-Revised in Swedish and Portuguese exercisers. *Measurement in physical education and exercise science*, *13*(3), 166-179. https://doi.org/10.1080/10913670903050313
8. O sportu. (25.4.2023). Dostupno na O sportu (hrvatski-sambo-savez.hr)
9. Szabo, A. & Griffiths, M. D. (2007). Exercise addiction in British sport science students. *International Journal of Mental Health and Addiction*, *5*, 25-28. https://doi.org/10.1007/s11469-006-9050-8
10. Taheri, M., Irandoust, K. & Razipoor, M. (2017). The study of eating disorders and body image among elite martial arts athletes. *Int J Med Res Health Sci*, *6*, 108-12.
11. Terry, A., Szabo, A. & Griffiths, M. (2004). The exercise addiction inventory: A new brief screening tool. *Addiction Research & Theory*, *12*(5), 489-499. https://doi.org/10.1080/16066350310001637363
12. Tremblay, M. S., Inman, J. W. & Willms, J. D. (2000). The relationship between physical activity, self-esteem, and academic achievement in 12-year-old children. *Pediatric exercise science*, *12*(3), 312-323. https://doi.org/10.1123/pes.12.3.312
13. Vina, J., Sanchis-Gomar, F., Martinez-Bello, V. & Gomez-Cabrera, M. C. (2012). Exercise acts as a drug; the pharmacological benefits of exercise. *British journal of pharmacology*, *167*(1), 1-12. https://doi.org/10.1111/j.1476-5381.2012.01970.x
14. Vizintin, M. & Baric, R. (2013). Ovisnost o vježbanju–spolne razlike. *Hrvatski športskomedicinski vjesnik*, *28*(2), 71-80.

Monitoring Sleep, Wellness, and Training Load in Recreational Crossfit Athletes

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ABSTRACT

CrossFit, a rapidly growing high-intensity functional training method, is practiced in 142 countries across the globe, with over 10,000 affiliates. It has motivated countless individuals to incorporate regular exercise into their daily lives, emphasizing ten general physical skills such as endurance, strength, flexibility, and speed. Nine participants (avg. age: 32 years) engaged in CrossFit training (avg. 2.8 years) where involved in this study. They completed three weekly sessions and were assessed for various parameters during a 14-day microcycle. Training load, assessed by multiplying training duration by perceived exertion, showed no significant differences between sessions. The participants found the first session the most challenging and the third to be the easiest. Weekly training loads remained consistent. Wellness was assessed daily, the highest values where observed on the thirteenth day and the lowest on the eighth. Sleep duration avg. 432.5 minutes in the first week and 449.2 minutes in the second, with the shortest sleep duration on the fourth day (397 minutes) and the longest on the ninth (473 minutes). Correlations between training load and wellness parameters indicated significant associations with fatigue, muscle soreness, and the overall wellness index. No significant correlations with stress, sleep quality, mood, or sleep duration where found. In conclusion, this study highlights the impact of external factors on wellness and the perceived exertion of CrossFit athletes. While fatigue and muscle soreness closely relate to perceived exertion, stress and sleep quality are influenced by external psychological factors.

INTRODUCTION

CrossFit is one of the fastest-growing functional training methods with an emphasis on high-intensity workouts. It is present in 142 countries across seven continents, boasting over 10,000 affiliates. It has inspired countless individuals to incorporate regular exercise into their lifestyles and has helped many people connect challenging physical work with a sense of accomplishment. CrossFit encompasses ten general physical skills: cardiovascular / respiratory endurance, stamina, strength, flexibility, power, speed, coordination, agility, balance, and accuracy, which are represented through movements and elements from gymnastics, Olympic weightlifting, and metabolic conditioning (functional endurance). Like any other sport, CrossFit has its professional athletes, amateurs, and recreational participants, with sporting events ranging from professional competitions to amateur and recreational or charitable events. The key to the CrossFit method lies in the concept that it is "the sport of fitness," aiming

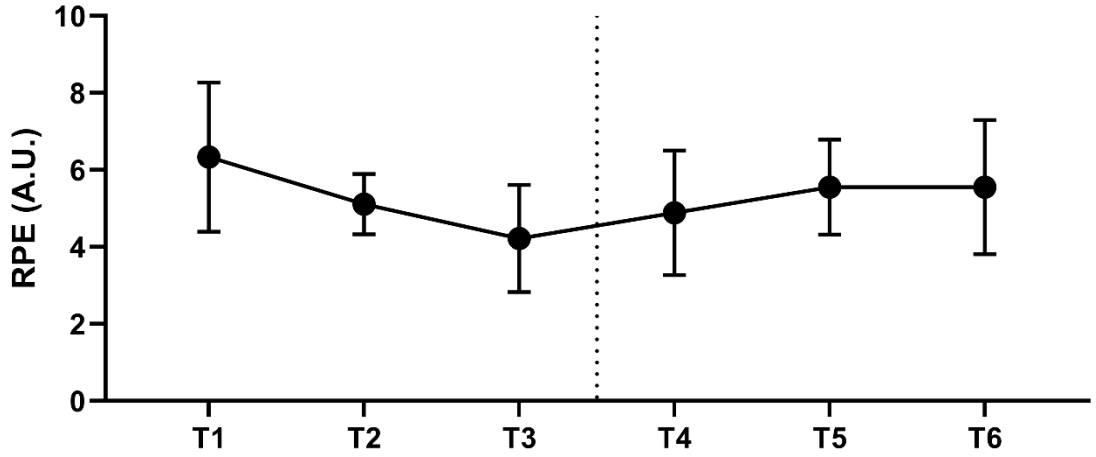
to harness the "natural camaraderie, competition, and fun in sport" by maintaining records, workout schedules, and defining rules and performance standards. Just like in any sport, monitoring the readiness and fatigue of athletes in professional CrossFit facilitates the evaluation and adjustment of training units and programs. Monitoring fatigue aims to optimize the training process for the purpose of improving performance and ensuring the safe execution of training elements. Tracking an athlete's condition immediately after a training session provides the coach with information on whether the training session had a targeted impact on the athlete's body. Meanwhile, monitoring an athlete's condition before the training process offers insight into the athlete's readiness prior to the training session and the potential need for program adjustments. Questionnaires and training logs (for fatigue) are a simple, cost-effective, and quick approach to monitoring an athlete's response to training. However, their effectiveness depends on how they are conducted and who fills them out. The modern era has allowed coaches to rely on other contemporary methods of monitoring athlete readiness. Monitoring sleep quality is one such method that provides modern coaches with information about an athlete's readiness for a new training session. Sleep, with its physiological and cognitive components, is considered one of the crucial factors in recovery and athlete readiness (Knufinke et al., 2018). Lack of sleep can have significant negative effects on health, sports performance, memory, learning, pain perception, weakened immunity, and more. Chronic or partial sleep disturbances can also impact changes in the body's metabolism, including alterations in glucose levels and neuroendocrine function, carbohydrate metabolism, appetite, food intake, and protein synthesis. Recommendations of 8 hours of sleep at night come from studys in wich limiting sleep to less than 6 hours per night for 4 or more consecutive nights can impair the aforementioned factors. Monitoring sleep quality is just one of the objective parameters that a coach can have at their disposal, while one of the simple and quick parameters for subjective assessment of workload is the RPE (Rate of Perceived Exertion) method for monitoring internal workload, as introduced by Borg in 1982. The RPE method requires athletes to subjectively assess the intensity of their entire workout using a rating scale ranging from 1 to 10. Immediately after each training session (within 5 minutes), athletes are asked to rate the perceived intensity of the workout. Athletes indicate the workout intensity by assigning a numerical value based on the RPE scale. The obtained intensity value is then multiplied by the total duration of the workout (in minutes), resulting in a measure of internal workload in arbitrary units. Every training unit and cycle of training units imposes a certain stress on the athlete's body. By using adequate methods to monitor the athlete's readiness, coaches can safely control and track the intensity and volume of each training unit within a training program. Based on the feedback received, the coach is able to make necessary adjustments to achieve the predetermined goals set for the athlete or sports team. Therefore, the aim of this paper is to monitor certain parameters of sleep, wellness, and subjective workload assessment in recreational CrossFit athletes during a single microcycle.

METHODS

The sample for this study consisted of a total of 9 participants (age: 32 ± 7.3 years, body weight: 75 ± 11.2 kg, height: 179.6 ± 5.8 cm, body mass index: 23.2 ± 2.6 kg·m²). There were 6 male and 3 female participants who had been engaged in CrossFit® training for at least one year (2.8 ± 2.5 years), with a minimum training frequency of three sessions per week. Inclusion criteria for the study were: i) possessing a valid sports health certificate, ii) all participants were in good health with no pain or injuries in the past year. The training load of each workout (sRPE) was determined by multiplying the duration of the training session (in minutes) by the subjective assessment of the workload. To quantify the perceived effort of participants after each training session, a modified ratio-category scale of subjective workload assessment (CR-10; Foster et al., 2001), originally developed by Borg (1982), was used. During the experimental period, participants completed a wellness questionnaire (McLean et al., 2010) based on recommendations by Hooper et al. (1995). The questionnaire assessed their fatigue, sleep quality, general muscle soreness, stress levels, and mood on a Likert scale from 1 to 5. The overall well-being of the participants was then determined by summing the scores of all five sub-categories. The questionnaire results served as the variable for assessing wellness. In order to determine how much time participants spent sleeping during the study, a Xiaomi MI Band 5 wristband was used, with its metric characteristics previously established (Concheiro-Moscoso et al., 2021). Descriptive statistics of the variables were presented by calculating the mean ± standard deviation (SD), and the normality of variable distributions was confirmed using the Shapiro-Wilks test. Due to the presence of "missing" data, a missing data analysis was conducted using the Little's Missing Completely at Random (MCAR) test, which determined that the data were missing completely at random, rather than due to systematic bias (χ^2 = 107.03, p = 0.79). Consequently, the missing data were imputed using the Multiple Imputation method. This method replaces missing values with pseudo-/random values based on observed values within the dataset for a given individual while retaining the other values in the data matrix (Azur et al., 2011). To assess the relationship between training load and wellness parameters and sleep duration, the Pearson correlation coefficient was used. The size of correlations was also determined using the modified Hopkins scale (2000): r, 0.1, trivial; 0.1-0.3, small; 0.3-0.5, moderate; 0.5-0.7, large; 0.7-0.9, very large; >0.9, almost perfect. Additionally, to determine whether there were differences in training loads across individual training sessions, a repeated measures ANOVA was employed, along with the associated effect size (partial eta - η^2) with values considered as small (0.01), medium (0.06), and large (0.14) effects (Cohen, 1988). Mauchly's test confirmed that the assumption of sphericity was met (F = 2.41, p = 0.06). The level of statistical significance was set at 0.05 for the analysis. All data were analyzed using the statistical software Statistica 14.0 (Dell Inc., Round Rock, TX USA). All participants who took part in the research provided written consent after being thoroughly informed about the purpose, benefits, and potential risks of the study, in accordance with the Ethical Code of the World Medical Association (Declaration of Helsinki). The University Ethics Committee followed

ethical standards for human studies and approved all experimental procedures.

RESULTS and DISCUSION



Graph 1. Presentation of subjective workload assessment during each training session: T - number of the training unit (session), RPE - rate of perceived exertion, A.U. - arbitrary units.

The values of subjective workload assessment during each training session provided by the participants are depicted in Graph 1. Using repeated measures ANOVA, it was determined that there were no significant differences between the training units ($F = 1.75$, $\eta^2 = 0.18$, $p = 0.15$). The participants found the first training session the most challenging and the third one the easiest. The daily training load, expressed in minutes, ranged from 207 to 320 arbitrary units. As for the weekly training load, it amounted to 1020 arbitrary units for both weeks.

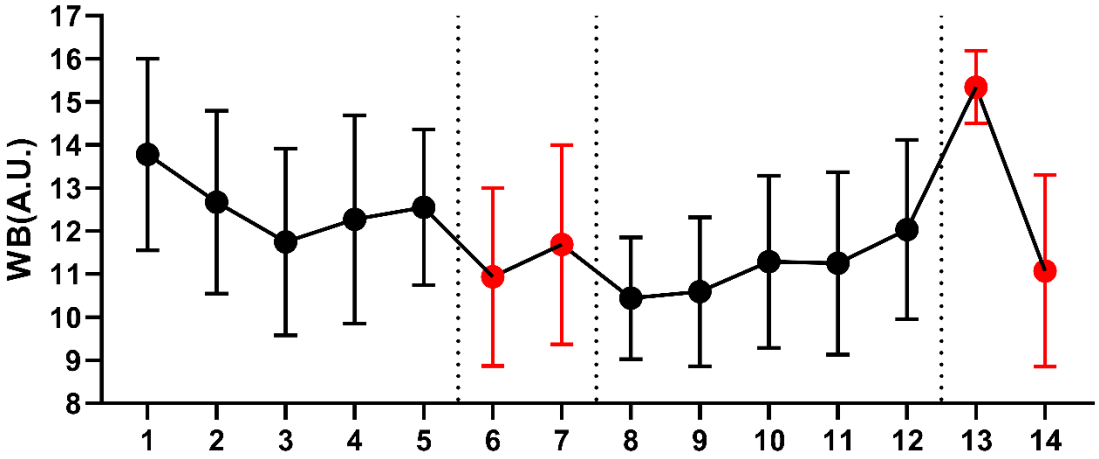


Figure 1. Wellness questionnaire values for each day during the study; WB - wellness questionnaire; A.U. - arbitrary units.

The values of the wellness questionnaire that participants provided each day during the study are presented in Graph 2. Weekends, during which participants did not have training on two days, are highlighted in red. The highest value was recorded on the thirteenth day, while the lowest was on the eighth day.

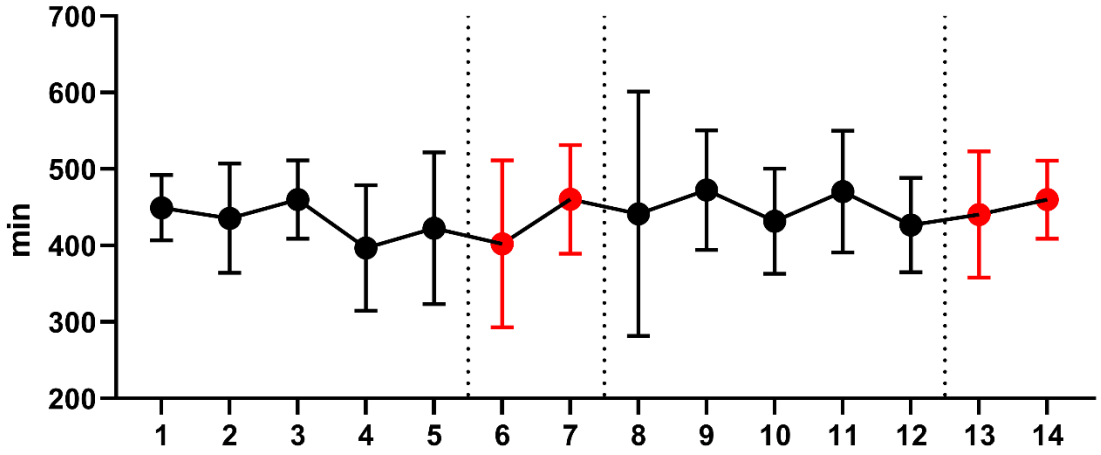


Figure 2. Sleep duration for each day during the study.

The values of sleep duration for each day that participants had are depicted in Graph 3. When comparing the average sleep duration per week, participants spent slightly more time sleeping during the second week (1st week = 432.5 min; 2nd week = 449.2 min). The least amount of sleep was on the fourth day of the study (397 minutes), while the longest duration was on the ninth day (473 minutes).

Table 1. Display of the correlation between average daily training load and the 5 sub-scales of the wellness questionnaire, the wellness index, and the average sleep duration during the study.

Variable	*mean*	*SD*	*r*	*p*
TLw	*316.67*	*48.48*		
Fatigue	*2.26*	*0.31*	*0.78*	*(0.01)*
Sleep quality	*3.00*	*0.36*	*0.19*	*(0.63)*
Muscle pain	*2.32*	*0.32*	*0.74*	*(0.02)*
Level of stress	*2.59*	*0.35*	*0.48*	*(0.19)*
Mood	*2.03*	*0.20*	*0.64*	*(0.06)*

WBi	*12.18*	*1.07*	*0.8*	*(0.01)*
SLEEPw	*436.46*	*60.01*	*-0.05*	*(0.9)*

Abbreviations: w -weekly, WBi - wellness questionnaire index; AS - arithmetic mean; SD – standard deviation; r - correlation coefficient; p - level of significance.

Table 1 displays the correlations between training load and wellness parameters as well as sleep duration during the 14-day microcycle. According to the obtained results, significant correlations are observed only with the wellness variables. Specifically, significant correlations were found with the sub-scales of fatigue and muscle soreness, as well as with the questionnaire index. These findings are in line with previous research where statistically significant correlations were also found with fatigue and muscle soreness (Thorpe et al., 2015). Such results are expected given the sensitivity of muscle pain and perceived fatigue to variations in perceived training load. The association can be explained considering the participants' experience in perceiving physical exertion, as CrossFit participants usually come from other sports (Manzi et al., 2010). On the other hand, the quality of sleep, stress levels, and mood can be more influenced by psychological factors outside of training. Sources of stress can be independent of training load, mainly considering psychological dimensions as negative aspects (expectations, negative interpersonal relationships, the demanding nature of the job itself that participants work in, and employment-related problems (Noblet & Gifford, 2002). Additionally, the lack of consistency in the relationship between training load and sleep duration can be explained by the fact that the study was not conducted in laboratory conditions. Aspects of sleep hygiene, such as circadian timing and sleep, lifestyle, daily responsibilities, as well as physiological aspects like fitness, had a negative impact on participants' sleep (Youngstedt et al., 1997). Therefore, all these factors disrupted the potential influence of training load on the sleep duration. The significant relationship between training load and the wellness questionnaire index is expected, considering the established validity and reliability for monitoring training load in various sports (McLean et al., 2010; Sawczuk et al., 2018).

CONCLUSION

The primary objective of this study was to monitor certain parameters of sleep, wellness, and subjective workload assessment in recreational CrossFit athletes during a single microcycle. Based on the obtained results, it can be concluded that various external factors can influence stress and other wellness parameters, limiting the generalizability of the findings. Future research should investigate the relationship between wellness categories and external training load to confirm the results of this experiment. In summary, it can be concluded that fatigue and muscle soreness are more closely related to perceived exertion than stress, sleep quality, mood, and sleep duration in CrossFit recreational athletes. In addition to daily assessments of wellness and sleep duration, weekly analyses of these factors could assist coaches in better understanding the impact of training load on the physical health of athletes.

REFERENCES

1. Borg (1982). Psychophysical bases of perceived exertion. Medicine and Science in Sports and Exercise, 14(5), 377-381
2. Cohen, J. (1988). Statistical power analysis for the behavioral sciences. Routledge Academic.
3. Concheiro-Moscoso, P., Martínez-Martínez, F. J., Miranda-Duro, M. D. C., Pousada, T., Nieto-Riveiro, L., Groba, B., ... & Pereira, J. (2021). Study Protocol on the Validation of the Quality of Sleep Data from Xiaomi Domestic Wristbands. International journal of environmental research and public health, 18(3), 1106.
4. Foster, C., Florhaug, J.A., Franklin, J., Gottschall, L., Hrovatin, L.A., Parker, S., Doleshal, P., & Dodge, C. (2001). A new approach to monitor exercise training. Journal of Strength and Conditioning Research, 15(1), 109-115.
5. Hooper SL, Mackinnon LT. Monitoring overtraining in athletes: recommendations.
6. Hopkins, W., Marshall, S., Batterham, A., & Hanin, J. (2009). Progressive statistics for studies in sports medicine and exercise science. Medicine+ Science in Sports+ Exercise, 41(1), 3.
7. Knufinke, M., Nieuwenhuys, A., Geurts, S. A. E., Coenen, A. M. L., & Kompier, M. A. J. (2018). Self-reported sleep quantity, quality and sleep hygiene in elite athletes. Journal of Sleep Research, 27(1), 78–85. https://doi.org/10.1111/JSR.12509
8. Manzi, V., D'Ottavio, S., Impellizzeri, F.M., Chaouachi, A., Chamari, K., & Castagna, C. (2010). Profile of weekly training load in elite male professional basketball players. Journal of Strength and Conditioning Research, 24(5), 1399-1406. doi: 10.1519/JSC.0b013e3181d7552a
9. McLean, B. D., Coutts, A. J., Kelly, V., McGuigan, M. R., & Cormack, S. J. (2010). Neuromuscular, endocrine, and perceptual fatigue responses during different length between-match microcycles in professional rugby league players. International journal of sports physiology and performance, 5(3), 367-383.
10. Noblet, A.J., & Gifford, S.M. (2002). The sources of stress experienced by professional Australian footballers. Journal of Applied Sport Psychology, 14(1), 1-13. doi: 10.1080/10413200209339007
11. Saw, A. E., Main, L. C., & Gastin, P. B. (2015). Monitoring Athletes Through Self-Report: Factors Influencing Implementation. Journal of Sports Science & Medicine, 14(1), 137.
12. Sawczuk, T., Jones, B., Scantlebury, S., & Till, K. (2018). Relationships between training load, sleep duration, and daily well-being and recovery measures in youth athletes. Pediatric exercise science, 30(3), 345-352.
13. Sławińska, M., Stolarski, M., & Jankowski, K. S. (2018). Effects of chronotype and time of day on mood responses to CrossFit training. https://Doi.Org/10.1080/07420528.2018.1531016, 36(2), 237–249.
14. Thorpe, R.T., Strudwick, A.J., Buchheit, M., Atkinson, G., Drust, B., & Gregson, W. (2015). Monitoring fatigue during the in-season competitive phase in elite soccer players.

International Journal of Sports Physiology and Performance, 10(8), 958-964. doi: 10.1123/ijspp.2015-0004
15. Youngstedt, S. D., O'connor, P. J., & Dishman, R. K. (1997). The effects of acute exercise on sleep: a quantitative synthesis. Sleep, 20(3), 203-214.

Heart Rate and Lactate Concentration During Amateur Boxing Matches – A Brief Review

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ABSTRACT

Amateur boxing involves intense, intermittent bouts of activity interspersed with periods of rest. Heart rate monitoring plays a vital role in training planning, while activity analysis identifies key technical and tactical elements for success. This paper adhered to Cochrane Collaboration guidelines and followed the PRISMA systematic review strategy. Electronic databases were searched up to September 1, 2021, using specific keywords. Two authors independently reviewed titles, abstracts, and references of potential publications. Inclusion criteria followed the PICO framework, ensuring the relevance of selected studies. Exclusion criteria encompassed non-peer-reviewed literature, studies on female boxers, animal research, and non-English papers. Methodological assessment utilized a modified checklist assessing reporting, validity, bias, confounding, and power. Data extraction followed Cochrane guidelines for systematic reviews. This systematic review analyzed 10 relevant studies on heart rate and lactate concentration in amateur boxing. The research indicates that amateur boxing is characterized by high-intensity bouts, requiring a well-developed aerobic system and effective management of unfavorable biochemical conditions. Lactate values cross aerobic and anaerobic thresholds in the first round, continuing to rise with each subsequent round. Heart rates often exceed 90% of the maximum, emphasizing the importance of aerobic conditioning for recovery. Training above the anaerobic threshold extends the time at high intensity before fatigue. Focusing on the alactate component and recovery strategies can further enhance performance in amateur boxing.

INTRODUCTION

Boxing is a high-intensity activity characterized by intermittent bouts of effort (Slimani et al., 2017). Short periods of intense activity alternate with longer periods of lower activity, i.e., active and passive rest. A boxer needs a well-developed aerobic system to sustain repeated attacks throughout the match and ensure better recovery between rounds. The popularity of amateur boxing as a sport is evident from the fact that AIBA - "Amateur International Boxing Association," the main international governing body, has affiliations with nearly 200 countries, and it is also an Olympic sport. Heart rate is defined as the number of heart muscle contractions in one minute. It can vary significantly due to various factors, including some such as the level of physical activity, stress, genetics, physical fitness, and illness. Resting heart rate values for a healthy adult range from 60 to 100 beats per minute. Monitorning the heart rate of athletes, during exercise and rest, is crucial for effective training planning. Analyzing activity can

significantly assist in determining physiological responses. Activity analysis involves identifying and describing elements of a particular sport and evaluating their contribution to overall success. This analysis reveals which technical and tactical elements of a sports activity are most crucial for victory and, accordingly, where the most attention should be focused in preparation. Davis et al. (2015) conducted such an activity analysis for elite-level matches, where winners had a higher number of total landed punches and a lower ratio of thrown to landed punches in the third round compared to the losers. The number of rear uppercuts was also higher for winners in the second and third rounds, while the number of defensive movements used was lower for winners. Similar data were obtained in a study conducted by Ashker (2017). It has been shown that winners possess more developed offensive abilities aimed at both the head and body, a higher number of punches with both hands, combinations, and, contrary to Davis's research, defensive capabilities. The data emphasize the importance of landing as many punches as possible, both individually and in combination, to score more points than the opponent. The same rules apply at the beginner level, as seen in a study conducted by Davis, Wittekind, and Beneke (2013). Winners landed more jabs in the first round, more total head punches, more combinations, and more punches thrown from a block or counter. With these insights, we can say that, from the perspective of physical preparation, the main goal of boxing training is to enable the fighter to effectively manage technical-tactical elements while efficiently dealing with the physiological demands of the fight (Slimani et al., 2017). Therefore, the aim of this paper is to systematically evaluate research related to heart rate and lactate concentration during amateur boxing matches. A summary of research on heart rate and lactate concentration will facilitate the transfer of information from science to practice. Boxing coaches will gain precise insights into the requirements of boxing matches, helping them create higher-quality training programs. Additionally, it will provide information for future scientific research in this field.

METHODS

Cochrane Collaboration guidelines where followed in this paper. The systematic review strategy was conducted following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analysis) guidelines (Moher et al., 2016). Search Strategy: electronic databases (Web of Science) were searched for relevant publications up to September 1, 2021. Key terms and synonyms were entered as free-text terms in the title and/or abstract using Boolean logic with AND / OR operators: "taekwondo" combined with "heart AND rate" and "lactate." In addition, manual searches of the references of retrieved publications were conducted to identify potentially eligible studies not covered by electronic searches. Inclusion/Exclusion Criteria: Two authors independently conducted a review of titles, abstracts, and reference lists of each publication to identify potentially relevant research. In addition, full versions of included publications were thoroughly examined to identify articles that met the selection criteria. The studies were included in the systematic review if they met the criteria outlined in the PICO framework (Patient/Population, Intervention, Comparison, Outcome). The PICO framework encompasses the population or groups under investigation, the intervention on the population, a comparative intervention or control, and the

outcome or result of the intervention (Schardt et al., 2007). Excluded were studies that did not meet the mentioned PICO criteria, including: 1) Systematic reviews and meta-analyses, reviews, comments, interviews, or expert opinions, letters to the editor, book chapters, and books, dissertations, and conference papers. Literature that was not peer-reviewed was rejected to retain only high-quality studies. 2) Research conducted on female boxers. 3) Studies conducted on animals. 4) Papers that were not written in the English language. Methodological assessment was performed using a modified version (Simic et al., 2011) of the original checklist (Downs & Black, 1998). This checklist consists of 27 items that assess 5 dimensions: (1) reporting; (2) external validity; (3) bias (intervention and outcome measurement); (4) confounding (selection bias); and (5) power. Each question is scored as 0 (poor quality) or 1 (good quality), except for question no. 5 ("clear description of the confounding variable"), which is scored from 0 (not met) to 2 (completely met). Each study can achieve a maximum of 28 points. The quality of the studies is classified based on the following thresholds: (i) poor (<14 points); (ii) fair (14-18 points); (iii) good (19-23 points); and (iv) excellent (24-28 points). Data extraction was prepared in a Microsoft Excel table following the Cochrane Consumers and Communication Review Group data extraction template (Prictor & Hill, 2013).

RESULTS and DISCUSION

Initially, a total of 1552 titles were identified. These publications were then exported to reference management software (EndNote, Clarivate Analytics, USA). Duplicates (1003 references) were subsequently removed automatically or manually. Further analysis led to the removal of 512 references after assessing their relevance through titles and abstracts. After a careful examination of the full texts, 37 articles were excluded, leaving 10 that met the inclusion criteria for discussion. The characteristics of the studies included in the systematic review can be found in Table 1. Most of the studies involved elite fighters (n = 7), with only one study sampling beginners, fighters with no prior competitive experience. In four studies, parameters of lactate concentration and heart rate were obtained during competition. Regarding the age of the participants, they were mostly in the senior or junior senior age category. Furthermore, six studies included round durations following current rules (3 x 3 minutes).

Table 1. Methodological quality (Mq) and research characteristics

Research	*Mq*	*n*	*age mean±SD*	*level*	*Type of Fight*	*Duration*
(El-Ashker et al. , 2018)	*21*	*11*	*21.4±2.1*	*Elite*	*Sparring*	*3x3min*
(de Lira i et al, 2013)	*22*	*10*	*17.9 ± 1.8*	*Regional*	*Sparring*	*3x2min*
(Nassib i et al, 2017)	*22*	*15*	*19.56 ±3.6*	*Elite*	*Competition*	*3x3min*
(Hanon i et al, 2015)	*20*	*28*	*21.5±2.1*	*Elite*	*Competition*	*3x3min*
(Smith, 2006)	*18*	*29*	*Seniors*	*International*	*Competition*	*3x3min*
		20	*Seniors*			*3x3min*

		6	*Seniors*			*5x2min*
		75	*Seniors*			*4x2min*
		24	*Juniors*			*4x2min*
(Davis et al, 2013)	*22*	*32*	*19.3 ± 1.4*	*Beginners*	*Competition*	*3x2min*
(Hukkanen i Häkkinen, 2017)	*21*	*7*	*20.3 ± 2.7*	*Elite*	*Sparring*	*3x3min*
(Ghosh, 2010)	*20*	*6*	*21.4 ± 3.0*	*Elite*	*Sparring*	*6x2min*
(Khanna & Manna, 2006)	*23*	*21*	*17.5 ± 1.5*	*Elite*	*Sparring*	*3x2min*
(Kılıc et al, 2019)	*22*	*20*	*25.88 ± 3.27*	*Elite*	*Sparring*	*3x3min*

All participants had to be able to tolerate an unfavorable biochemical situation throughout the entire match. First, let's compare matches lasting 3 x 3 minutes. Nassib et al. (2017) reported an average lactate value of 8.87 ± 2.02 mmol/L measured 3 minutes after the end of the match. Hanon et al. (2015) presented values by weight categories, also measured 3 minutes after the end of the match. The lowest values were observed in the lightest category among those measured (-48kg, 11.4 ± 1.5 mmol/L) and the heaviest category measured (-91kg, 11.6 ± 2.9 mmol/L). Following that, there is a progressive increase in values by weight categories, with the highest value in the under 64kg category (17.0 ± 2.3 mmol/L), which are significantly higher figures than those in Nassib et al.'s (2017) study. For two different groups of senior boxers, Smith (2006) reported average lactate values of 12.8 and 9.5 mmol/L measured approximately 4 minutes after the end of the competitive match. Hukkanen and Häkkinen (2017) measured lactates after each round of simulated matches in the pre-competitive and competitive periods. For the pre-competitive period, the results measured at the end of each round were as follows: T1 10 ± 1 mmol/L, T2 14 ± 2 mmol/L, T3 17 ± 2 mmol/L, similar to the highest values measured in Hanon et al. (2015). In the competitive period, as expected, lower values were measured: T1 9 ± 1 mmol/L, T2 12 ± 3 mmol/L, T3 13 ± 3 mmol/L. The results are similar to those in Hanon et al.'s (2015) study, considering the weight categories to which participants in both studies belong. It is important to note the change in lactate values measured after a fifteen-minute warm-up for this study. In the pre-competitive period, lactates were as follows: T0 5 ± 1 mmol/L, and in the competitive period, T0 3 ± 1 mmol/L. Additionally, Kılıc et al. (2019) reported an average value of 12.21 mmol/L measured within 10 minutes after the end of a competitive match for international-level fighters. We can conclude that lactate values in amateur boxing matches begin to rise sharply from the first minutes of the fight, as observed in Hukkanen and Häkkinen's (2017) measurements after the first round. Recorded values of 10, and 9 ± 1 mmol/L indicate the transition of both the aerobic and anaerobic thresholds, i.e., the maximum lactate steady state, as early as in the first round. Values continue to increase at a somewhat more moderate pace during the second round (14 ± 2, and 12 ± 3 mmol/L). The one-minute rest between rounds is not sufficient for significant recovery and halting the rise in lactate values. In the third round, with the slowest rate of increase, they reach their maximum, the value of which depends on the fighter's weight category. According to the results of the presented research, for most

weight categories, this ranges from 12 to 14 mmol/L. Exceptions are at the extremes of the weight spectrum – the category up to 48kg and the one up to 91kg, which have slightly lower recorded values. The highest values were recorded in the up to 64kg category in Hanon et al.'s (2015) study (17.0 ± 2.3 mmol/L) and in Hukkanen and Häkkinen's (2017) study (T3 17 ± 2 mmol/L, i.e., T3 13 ± 3 mmol/L) whose participants belong to the middleweight categories. For 3 x 2-minute matches, Davis et al. (2013) reported an average value of 11.8 mmol/L measured in beginners after a competitive match, while Khanna and Manna (2006) distributed results measured after simulated matches by the weight categories of the fighters. They report the following values: for the lighter weight categories (<54 kg) 11.4 ± 0.9, for the middle ones (<64 kg) 10.8 ± 1.4, and for the middleweight categories (as stated in the article, <75 kg) 13.1 ± 0.9 mmol/L. As expected, the values are lower than in 3 x 3-minute matches. Nevertheless, there is a significant difference in the values of the <64 kg category in this study compared to Hanon et al. (2015). As for heart rate, in 3 x 3-minute matches, El-Ashker et al. (2018) record a progressive increase over rounds. Like lactate, heart rate has a sharp rise from the beginning of the match due to the high activity level, and at the end of the first round, it reaches values of 176 ± 4.1 bpm, which is 90 ± 2.2% of the maximum for these participants. A well-developed aerobic system helps with recovery between rounds, but 1 minute of rest is not enough; values increase with each subsequent round to 179 ± 1 (91 ± 1.4%) and 182 ± 5 bpm (92 ± 2.3%). Nassib's average values during the match are reported as 172.75 ± 6.84 bpm. In Hukkanen and Häkkinen's (2017) study, we also have the same pattern of increasing values over rounds, with slightly higher values; 183 ± 6, 185 ± 5, 191 ± 7 bpm. In 3 x 2-minute matches, de Lira et al. (2013) again show an increase over rounds with values of 175 ± 11 for the first, 183 ± 6 for the second, and 186 ± 7 bpm for the third round. Relative heart rate reaches higher values than in El-Ashker et al. (2018): 91 ± 5 for the first, 95 ± 3 for the second, and 96 ± 2% for the third round. Similar heart rate values to those in El-Ashker et al. (2018) with shorter match duration can be explained by the difference in the boxing quality of the participants – national level in El-Ashker et al. (2018) and regional in de Lira et al. (2013). Furthermore, we observe the same trend of increasing values over rounds in Khanne's study, across all weight categories.

CONCLUSION

Amateur boxing is characterized by alternating high-intensity attacks with short periods of active and passive rest. An activity analysis conducted by Slimani et al. (2017) reveals an activity-to-rest ratio of 18:1 in elite amateur boxers. Such a high level of activity requires a well-developed aerobic system that enables repeated attacks throughout the entire match and ensures better recovery between rounds. Additionally, effective tolerance of unfavorable biochemical conditions throughout the match is necessary. Reported lactate values of 10, or 9 ± 1 mmol/L, indicate the crossing of both aerobic and anaerobic thresholds, i.e., the maximum lactate steady state, as early as the first round. With each subsequent round, lactate values increase. Most amateur boxing matches are conducted at an intensity level above 90% of the maximum heart rate, with peak values potentially exceeding 95%. Emphasizing high-quality training to develop the aerobic system allows for maximum utilization of any breaks

in activity, especially between rounds, to facilitate better recovery and faster reduction of heart rate. Moreover, training above the anaerobic threshold, above 80% - 90% of VO2max, extends the time an athlete can spend at that intensity before fatigue sets in. Finally, it is advisable to work on the alactate component, engaging in short-duration activities of maximum intensity with sufficient time for recovery between repetitions.

REFERENCES

1. Ashker, S. El. (2017). Technical and tactical aspects that differentiate winning and losing performances in boxing. *Http://Dx.Doi.Org/10.1080/24748668.2011.11868555*, *11*(2), 356–364. https://doi.org/10.1080/24748668.2011.11868555
2. Davis, P., Benson, P. R., Pitty, J. D., Connorton, A. J., & Waldock, R. (2015). The Activity Profile of Elite Male Amateur Boxing. *International Journal of Sports Physiology and Performance*, *10*(1), 53–57. https://doi.org/10.1123/ijspp.2013-0474
3. Davis, P., Wittekind, A., & Beneke, R. (2013). Amateur Boxing: Activity Profile of Winners and Losers. *International Journal of Sports Physiology and Performance*, *8*(1), 84–92. https://doi.org/10.1123/ijspp.8.1.84
4. de Lira, C., Peixinho-Pena, L., Vancini, R., de Freitas Guina Fachina, R., de Almeida, A., Dos Santos Andrade, M., & da Silva, A. (2013). Heart rate response during a simulated Olympic boxing match is predominantly above ventilatory threshold 2: a cross sectional study. *Open Access Journal of Sports Medicine*, *4*, 175. https://doi.org/10.2147/OAJSM.S44807
5. Downs, S., & Black, N. (1998). The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. *Journal of Epidemiology and Community Health*, *52*(6), 377–384. https://doi.org/10.1136/JECH.52.6.377
6. El-Ashker, S., Chaabene, H., Negra, Y., Prieske, O., & Granacher, U. (2018). Cardio-Respiratory Endurance Responses Following a Simulated 3 × 3 Minutes Amateur Boxing Contest in Elite Level Boxers. *Sports (Basel, Switzerland)*, *6*(4). https://doi.org/10.3390/SPORTS6040119
7. Ghosh, A. (2010). Heart Rate, Oxygwn Consumption and Blood Lactate Responses During Specific Training in Amateur Boxing. *IJASS(International Journal of Applied Sports Sciences)*, *22*(1), 1–12. https://doi.org/10.24985/IJASS.2010.22.1.1
8. Hanon, C., Savarino, J., & Thomas, T. (2015). Blood lactate and acid-base balance of world-class amateur boxers after three 3-minute rounds in international competition. *Journal of Strength and Conditioning Research*, *29*(4), 942–946. https://doi.org/10.1519/JSC.0000000000000736
9. Hukkanen, E., & Häkkinen, E. (2017). Effects of Sparring Load on Reaction Speed and Punch Force During the Precompetition and Competition Periods in Boxing. *Journal of Strength and Conditioning Research*, *31*(6), 1563–1568. https://doi.org/10.1519/JSC.0000000000001885

10. Khanna, G. L., & Manna, I. (2006). Study of Physiological Profile of Indian Boxers. *Journal of Sports Science & Medicine*, *5*(CSSI), 90.
11. Kılıc, Y., Cetin, H. N., Sumlu, E., Pektas, M. B., Koca, H. B., & Akar, F. (2019). Effects of Boxing Matches on Metabolic, Hormonal, and Inflammatory Parameters in Male Elite Boxers. *Medicina*, *55*(6). https://doi.org/10.3390/MEDICINA55060288
12. Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., Shekelle, P., Stewart, L. A., Estarli, M., Barrera, E. S. A., Martínez-Rodríguez, R., Baladia, E., Agüero, S. D., Camacho, S., Buhring, K., Herrero-López, A., Gil-González, D. M., Altman, D. G., Booth, A., … Whitlock, E. (2016). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Revista Espanola de Nutricion Humana y Dietetica*, *20*(2), 148–160. https://doi.org/10.1186/2046-4053-4-1
13. Nassib, S., Hammoudi-Nassib, S., Chtara, M., Mkaouer, B., Maaouia, G., Bezrati-Benayed, I., & Chamari, K. (2017). Energetics demands and physiological responses to boxing match and subsequent recovery. *The Journal of Sports Medicine and Physical Fitness*, *57*(1–2), 8–17. https://doi.org/10.23736/S0022-4707.16.05958-2
14. Prictor, M., & Hill, S. (2013). Cochrane Consumers and Communication Review Group: leading the field on health communication evidence. *Journal of Evidence-Based Medicine*, *6*(4), 216–220. https://doi.org/10.1111/JEBM.12066
15. Schardt, C., Adams, M. B., Owens, T., Keitz, S., & Fontelo, P. (2007). Utilization of the PICO framework to improve searching PubMed for clinical questions. *BMC Medical Informatics and Decision Making*, *7*, 16. https://doi.org/10.1186/1472-6947-7-16
16. Simic, M., Hinman, R. S., Wrigley, T. V., Bennell, K. L., & Hunt, M. A. (2011). Gait modification strategies for altering medial knee joint load: a systematic review. *Arthritis Care and Research*, *63*(3), 405–426.
17. Slimani, M., Chaabène, H., Davis, P., Franchini, E., Cheour, F., & Chamari, K. (2017). Performance Aspects and Physiological Responses in Male Amateur Boxing Competitions: A Brief Review. *Journal of Strength and Conditioning Research*, *31*(4), 1132–1141. https://doi.org/10.1519/JSC.0000000000001643
18. Smith, M. S. (2006). Physiological Profile of Senior and Junior England International Amateur Boxers. *Journal of Sports Science & Medicine*, *5*(CSSI), 74.

Metric Characteristics of The Adriatic Zone Dances

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ABSTRACT.

The implementation of dance structures in Physical education (PE) classes in accordance with contemporary education that promotes gender equality and lifelong learning. The research was conducted with the basic aim of determining some metric characteristics (objectivity, sensitivity, homogenity and pragmatic validity) on the two Adriatic dance zone choreographies, *Linđo* from Dubrovnik and *Quatro passi* from Korčula, applicable in physical education classes. The sample of subjects consisted of 58 students, male and female students of kinesiology, 21-24 aged. Three judges evaluated the performance of each dance according to previously agreed evaluation criteria. According to the values obtained by the Kolmogorov-Smirnov test, the assessment of the three experts does not deviate from the Gaussian curve at the 0.05 significance level. Satisfactory values of the Cronbach's alpha coefficient (.93-.96) were determined, and the common variance of the expert variables through factor analysis explains 88% and 90% of the total common variance of the latent dimension. Choreography, in which the key segments are first evaluated, and then the segments' evaluations are added to the total score, the final evaluation of the complex motor pattern, was shown to be applicable to a sample of students of both gender. High correlation (.77 - .79) were found between the analysed newly constructed tests for assessment of dance skills and classical method of evaluation in physical education classes on Likert scale from 1 to 5. According to obtained results, the newly constructed tests for assessing Adriatic dance zone dance skills have satisfactory metric characteristics of sensitivity, objectivity, homogeneity and pragmatic validity and considered applicable in the teaching in PE.

Keywords: choreography evaluation, students, physical education

INTRODUCTION

The advantages of using dance structures in PE classes are numerous in the overall educational, physical and health status of children and young people. In addition to the fact that dance is an activity that has a positive effect on the overall anthropological status, dance as art in movement and stage art develops creativity, expression and improvisation and inclusive relationship with others. In this sense, special attention should be paid to folk dances that additionally develop a sense of national identity through familiarization with ethnochoreological dimension of Croatian history and folk dances as national treasure. Thus, through the application of dance and an interdisciplinary approach, inclusiveness and understanding between genders is especially developed in PE classes at an early age and continues throughout the lifelong learning. According to Srhoj & Miletić (2000), the

education component of dance in school practice occurs through four levels: national, social, aesthetic and health. Rehearsing pair dances in PE classes has an additional socialization and educational effect that especially contributes to fostering tolerance and understanding between boys and girls. Furthermore, the implementation of dance structures in PE classes is in accordance with contemporary education that promotes lifelong learning for a healthier and better life. Dancing, especially folk dancing is physical activity appropriate for people of all ages and creating a positive attitude related to learning to dance is important issue in contemporary education. Numerous researches emphasize the advantages of including dance structures in school programs at all levels of education (Gibbs, Quennerstedt & Larsson, 2017; Neville & Makopoulou, 2021; Mattsson & Larsson, 2021.). The results obtained on the samples of PE students will need to be further investigated on a sample of schoolchildren in order to enable the implementation of newly constructed tests to assess the level of performance of the Adriatic dance zone choreography in the school program. Furthermore, information about the level of performance of choreography is necessary in order to determine, through the process of planning and programming of PE classes, the optimal number of frequencies sufficient for the adopted specific dance structures. It is assumed that the tests for assessing the level of performance, which are researched on the student population, will be able to be adapted to assess the level of performance in primary and secondary school classes.

The main goal of the research is to evaluate some metric characteristics (objectivity, sensitivity and homogeneity and pragmatic validity) of newly constructed tests for assessing the level of performance of dance choreographies of the Adriatic dance zone (*Linđo* and *Quatro passi*).

METHODS

The research was conducted on a sample of 58 PE students aged 21 to 24, through the Theory and Methodology of Dance course. Students with previous dancing experience of folk dances did not participate in the research. Two dances of the Adriatic dance zone (*Linđo* from Dubrovnik and *Quatro passi* from Korčula) were selected for research because of their applicability in PE classes. The criteria for evaluating the choreography were determined, and three independent evaluators evaluated the level of performance of the choreography, without the possibility of mutual consultation. In the first phase of the learning process, the basic steps of dances were learned in a slow rhythm while counting beats. Then the parts of the choreography were rehearsed in the original rhythm with the music. In the second phase, dance choreographies were adopted, first with counting and slow rhythm in pairs, and then with music in the original rhythm of the dance. Evaluation of choreography by three independent evaluators is already investigated on a sample of students (Miletić 2022; Božanić & Miletić, 2011; Castillo & Espinosa, 2014). The evaluation was carried out so that the choreography was broken down into basic sequences or parts, and each sequence was evaluated with a score of 2 (if part of the choreography was performed correctly); 1 (if part of the choreography was performed partially correctly and 0 (if part of the choreography was not performed correctly). The total maximum score for each choreography was 10.

The methods for data analysis were chosen according to the set goal of the research, to analyse the metric characteristics of the newly constructed tests for assessing the level of performance of the choreography of the dances of the Adriatic dance zone, *Linđo* and *Quatro passi*. In order to analyse sensitivity, descriptive statistical parameters were calculated: arithmetic means (AS), standard deviations (SD), minimum scores (MIN), maximum scores (MAX), and the normality of distributions was checked with the Kolmogorov-Smirnov test (KS). In order to analyse the objectivity of the judges, the Cronbach alpha coefficient was calculated, and in order to analyse the homogeneity, the first main component was calculated through factor analysis. In order to analyse the pragmatic validity, a correlation was calculated between the results achieved on the newly constructed test and the results obtained by the classical method of evaluation on the Likert scale.

RESULTS and DISCUSION

Based on the results of descriptive statistics (Tables 1 and 2), it can be determined that the test items are distributed correctly, which means that the tests for assessing the performance of dance choreography of the Adriatic dance zone (*Linđo* and *Quatro passi*) are suitable for performing on the student population. With all three judges for both dances, we register a KS test that does not deviate significantly from the Gaussian curve at the error level of 0.05, and as such they have satisfactory sensitivity. The judges have uniform mean values in evaluating the *Linđo* and *Quatro passi* dances, and the second judge shows the mildest criteria in the evaluation of both dances. According to the results of the Cronbach alpha coefficients, both tests show good measurement characteristics of objectivity, which indicates clearly set and transparent criteria for evaluating the dance structures *Linđo* and *Quatro passi.*

Table 1. *Descriptive statistics, values of the Kolmogorov-Smirnov test (KS) and Cronbach's alpha (Alpha) for variable Linđo*

Linđo/evaluators	**Mean**	**Min**	**Max**	**SD**	**KS**	**ALPHA**
S1	6,95	2,00	10,00	2,55	.15	
S2	7,45	2,00	10,00	2,51	.20	
S3	7,22	3,00	10,00	2,22	.15	
∑ ***Linđo***	7,21	2,67	10,00	2,34	.14	.96

*KS test is significant on the level of 0.05 for: d<0.21 (when N=58)

Table 2. *Descriptive statistics, values of the Kolmogorov-Smirnov test (KS) and Cronbach's alpha (Alpha) for variable Quatro passi*

Quatro passi/evaluators	**Mean**	**Min**	**Max**	**SD**	**KS**	**ALPHA**
S1	7,38	4,00	10,00	1,80	.12	
S2	7,62	3,00	10,00	1,82	.19	
S3	7,52	4,00	10,00	1,58	.15	
∑ ***Qutro passi***	7,51	3,67	10,00	1,62	.10	.93

*KS test is significant on the level of 0.05 for: d<0.21 (when N=58)

The latent dimension in the space of evaluator variables (Table 3) explains 93% (*Linđo*) and 88% (*Quatro passi*) of the total variance of the system of items with a uniform and homogeneous projection of all judges on the common object of measurement. Correlation between the level of performance of dance choreographies, through newly constructed tests on a scale of 0 to 10 and the classic school method of assessing dance structures on a Likert scale of 1 to 5, for *Linđo* variable is .79, and for *Quatro passi* is .77. Therefore, analyze test have good pragmatic validity and choreographies could be evaluated by segments in school practice.

Table 3. *Structure of the latent dimension in the area of components of evaluators*

V	***Linđo***	***Quatro passi***
S1	-0,96	-0,93
S2	-0,96	-0,92
S3	-0,98	-0,96
Expl.Var	2,79	2,63
Prp.Totl	0,93	0,88

By inspecting and comparing the statistical parameters of both analyzed variables, we observe lower values of the parameters of objectivity and homogeneity in the choreography of the *Quatro passi* dance compared to the choreography of the *Linđo* dance. The process of determining the criteria for evaluating *Quatro passi* choreography was more difficult to objectively define. The evaluation was performed with music, and it is possible that the emphasized rhythm, accents in the music are connected with the movement, and the possibility of a clear number of bars influenced the easier selection of dance sequences, the setting of criteria, and thus the concordance of the judges in the evaluation phase. When it comes to the number of frequencies needed to practice the choreography, there is no difference in the analyzed dances, because both were practiced for the same amount of time and the results of the basic statistical sensitivity parameters do not differ significantly. Comparing the newly applied grading scale (0-10), which enabled a better differentiation of respondents, it is clear that it is consistent with the standard grading that is applied in school practice. With this research, it was confirmed that the evaluation criteria, appropriate tools for individual and objective evaluation of dance skills of adult beginners have been set. In this research, for the first time, the choreographies of the dances of the Adriatic dance zone are sequenced into parts, which are then separately evaluated according to the given criteria. Assessment is carried out based on dance segments, which are assumed to be easier to implement in PE classes. Evaluating choreography as a whole requires considerable experience of the evaluator and great concentration, and the possibility of error in evaluation increases the more complex the choreography. In the case of

evaluating individual parts of the choreography, as was carried out in this research, it is possible to determine which parts of the choreography need to be rehearsed in order to improve the overall performance. Sequential evaluation was also applied in the research by Aristidou at al. 2015 in which the LMA method is used. According to the obtained results of the LMA method, through the components of the body, form, space and activity, it can be effectively used to compare the quality and assess the quality of folk dances. According to Chen et al. (2011) LMA method is focused on the analysis of movement quality as well as the evaluation of the same, which was also the goal of this research. The methods of evaluating dance choreography by dividing it into segments can be used in other aesthetic activities as well as in synchronized swimming, which requires further research.

CONCLUSION

In conclusion, the newly constructed tests for assessing the level of *Linđo* and *Quatro passi* dance performance among PE students show good metric characteristics of sensitivity, objectivity and homogeneity and pragmatic validity. Their practical applicability is especially important in the system of modern and inclusive education and the development of transversal skills in students. Further research is needed to analyze the effectiveness of acquiring performance of dance structures and their evaluation at younger ages among school children, in order to determine the applicability of dance structures in PE practice.

REFERENCES

1. Aristidou, A., Stavrakis, E., Charalambous, P., Chrysanthou, Y., & Himona, S. L. (2015). Folk dance evaluation using laban movement analysis. *Journal on Computing and Cultural Heritage (JOCCH), 8*(4), 1-19.
2. Božanić, A. & Miletić, Đ. (2011). Differences between the sexes in technical mastery of rhythmic gymnastics. *Journal of Sports Sciences,* 29(4), 337-343.
3. Castillo, D. B., & Espinosa, A. A. (2014). Autocratic and participative coaching styles and its effects on students dance performance. *International Journal of Learning, Teaching and Educational Research*, *3*(1).
4. Chen, J. F., Lin, W. C., Tsai, K. H., & Dai, S. Y. (2011). Analysis and evaluation of human movement based on laban movement analysis. *Journal of Applied Science and Engineering*, *14*(3), 255-264. https://doi.org/10.6180/jase.2011.14.3.09.
5. Gibbs, B., Quennerstedt, M., & Larsson, H. (2017). Teaching dance in physical education using exergames. *European Physical Education Review*, *23*(2), 237-256.
6. Mattsson, T., & Larsson, H. (2021). 'There is no right or wrong way': exploring expressive dance assignments in physical education. *Physical Education and Sport Pedagogy*, *26*(2), 123-136.
7. Miletic, A. (2022). Distance learning in dance sport during the Covid-19 outbreak. Acta Kinesiologica 1, 141-147.

8. Neville, R. D., & Makopoulou, K. (2021). Effect of a six-week dance-based physical education intervention on primary school children's creativity: A pilot study. *European Physical Education Review*, *27*(1), 203-220.
9. Srhoj, Lj. & Miletić, Đ (2000). Plesne strukture (udžbenik). *Abel international.*

The Influence of Coordination Training on Specific Abilities ond Knowledge of Youth Soccer Players

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ABSTRACT

Coordination is an important prerequisite for a successful football player, and from an early age, training should focus on the development of coordination. The aim of this research is to determine the effects of four-week cycle of basic and specific coordination training on specific technical performance (guiding and passing the ball) and coordination skills between children football players. Sample of examinees consisted of 20 boys of the U13 category, after the initial testing, were divided into 2 groups, in a randomized way. In the first group, basic coordination training was conducted, while in the second group, specific coordination training was conducted, and together they did football training. During the four-week training cycle, the first group of children conducted basic full body coordination training with and without the ball, while the second group conducted specific coordination content of a football nature. During this period, 3 workouts per week lasting 45 minutes were performed. Both groups made statistically significant progress in specific coordination abilities, but there are no differences between the groups that could be attributed to the characteristics of each training program. The experimental group that implemented the specific coordination program in the final testing had better results, but numerically they are not statistically significant compared to the control group that implemented the basic coordination program. This research demonstrates that it is possible to develop coordination in young soccer players through a basic and specific coordination and agility program. Priority was given to the basic training program, making this group the experimental one because children at this age need to be exposed to a wider range of activities and programs to better develop fundamental skills that will help them in mastering specific athletic abilities. We can conclude that at this stage of development, it is essential to conduct training of both basic and sport-specific nature with the aim of developing coordination abilities.

Keywords: Developing, sport, ball, passing, U13

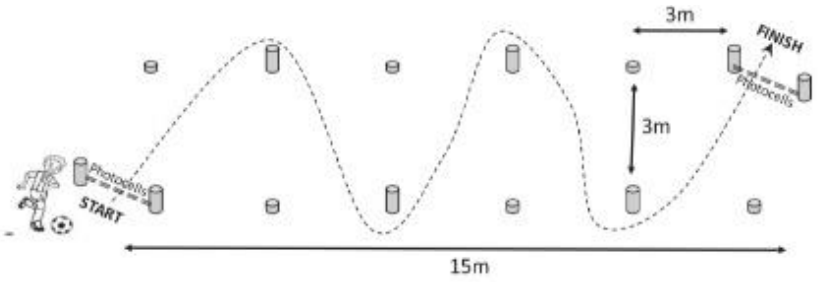
INTRODUCTION

Dujmović (2000) categorized football as one of the most popular sports in the world, as it transformed from a simple game into the "most important secondary thing in the world" in a short period. Football is a polystructural cyclic activity, played on a field that is 100 - 110 meters long, which classifies it as a relatively large field, while the duration of the match is 90 minutes, contributing to the demanding nature of the sport. Ball manipulation in football is done with the feet, while in most sports the ball is manipulated with the hands, which is significantly more demanding and difficult because hands are designed for "finer

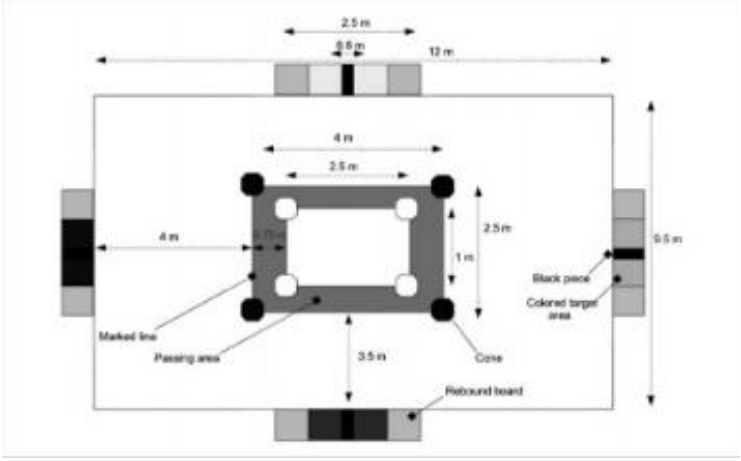
motor skills," and feet for "coarser" motor skills (Erceg, Rađa, and Sporiš, 2018). Motor abilities are defined in terms of intensity and extensity, meaning strength, speed, and duration of exercise, or the number of repetitions of a specific exercise (Gardašević, Georgiev and Bjelica 2012). They can also be described, measured, and assessed with the same set of measures, and they are influenced by physiological, morphological, biomechanical, and biochemical mechanisms (Zatsiorsky, 2002). Bompa (2000) defined coordination as the ability of a person to control the movements of their own body or only certain parts of the locomotor system. The sensitive phase is a period during which the development of a specific motor ability is most suitable, as the organism reacts very intensively to external stimuli during this period, with certain and appropriate developmental effects (Milanović, 2013). The sensitive phases for the development of coordination are between 7 and 14 years of age, with the most sensitive period being from 10 to 13 years of a child's life, and the development of coordination itself is considered the most important segment in training with children (Milanović, 2013). Considering that the heredity coefficient of coordination is 0.80, it is necessary to start developing this ability at the earliest age possible (Malacko, 1991). Motor abilities can be developed through various training methods, and there is a large number of procedures for their assessment (Zoranjić, Bašalić and Čović 2011). For the analysis of these abilities, tests are chosen that are most suitable and necessary at that particular moment (Vučetić and Sporiš, 2016). The aim of this research is to determine the effects of four-week cycle of basic and specific coordination training on specific technical performance (guiding and passing the ball) and coordination skills between children football players.

METHODS

20 participants took part in the research, children who are football players from the Football Club Zagreb, in the U13 category. Motor abilities and motor skills were measured using the "Loughborough Young Footballers Passing Test" and the "Zigzag Ball Control Test with Change of Direction" ("Loughborough test dodavanja za mlade nogometaše" i "Zig zag test vođenja lopte s promjenom smjera kretanja"). The "Loughborough Young Footballers Passing Test" (Le Moal et al., 2013) was used to assess precision, speed, and specific coordination, while the "Zigzag Ball Control Test with Change of Direction" (Bekris, Gissis, and Kounalakis, 2018) was used to assess specific coordination abilities (quick change of direction). The "Loughborough Young Footballers Passing Test" was measured twice in the initial and twice in the final testing, and the time is expressed in seconds, considering the average of the two attempts. The "Zigzag Ball Control Test with Change of Direction" was conducted three times in the initial and three times in the final testing, with the time expressed in seconds, and the arithmetic mean of the three attempts was considered.



Picture 1: Graphic representation of the "Zigzag Ball Control Test with Change of Direction" (Bekris, Gissis, and Kounalakis, 2018)



Picture 2: Graphic representation of the "Loughborough Young Footballers Passing Test" (Le Moal et al., 2014)

The athletes were randomly divided into two groups of 10 participants each. One group conducted basic coordination training (experimental group), while the other group underwent standard specific coordination training (control group). Both groups participated in the same football training. The training program lasted for four weeks, with a total of 12 sessions of basic or specific coordination training, i.e., three sessions per week, each lasting 45 minutes. Additionally, there were four football training sessions per week within the same group, totaling 16 football training sessions. The experimental group, which conducted basic coordination training, followed this training protocol: Standard dynamic warm-up with running school exercises: low skips, high skips, sidesteps, forward kicks, backward kicks, two-footed jumps, one-footed jumps, lateral movements, zig-zag movements, backward running, zig-zag backward running, and accelerations. After warm-up, dynamic stretching was performed, including forward lunges, side lunges, knee flexion (quadriceps stretching), hip and knee flexion, lateral lunges, and trunk rotations. The main part of the basic coordination training consisted of the following exercises: 1) Skip over cones with two entries: 12 cones were placed at a distance of two feet, and the exercise was performed by the athlete

skipping low over the cones. After passing three cones, the athlete performed a sidestep and passed the ball to the coach or a teammate. 2)Three forward, one backward: 12 cones were placed at a distance of two feet, and the athlete executed a low skip forward over three cones, followed by a backward skip over one cone. After that, the athlete performed a sidestep and passed the ball to the coach or a teammate. 3)Lateral movements: 12 cones were placed at a distance of two feet, and the athlete executed a sidestep after the third cone, changing direction. After the sidestep, the athlete passed the ball to the coach or a teammate. 4)Forward-backward: 12 cones were placed at a distance of 2 feet, and the athlete started in a lateral position, moving forward and backward between the cones. After every third cone, the athlete passed the ball to the coach or a teammate. These exercises were first performed five times without the ball, and then five times with the ball. The control group, which conducted specific coordination training, followed the same dynamic warm-up and stretching routine. The main part of their specific coordination training included the following exercises: 1) Receiving and playing with the dominant foot – inside of the foot: Athletes stood in pairs at a distance of 8 meters. While waiting for the ball, they executed low skips and approached the ball. The focus during ball reception was on the non-dominant foot. After receiving the ball, the athlete passed it sideways using the inside of the dominant foot. 2)Receiving and playing with the non-dominant foot – inside of the foot: Similar to the first exercise, athletes stood in pairs and executed low skips while waiting for the ball. The focus during ball reception was on the dominant foot. After receiving the ball, the athlete passed it sideways using the inside of the non-dominant foot. 3)Alternating reception and playing – inside of the foot: Athletes stood in pairs at an 8-meter distance, performing low skips while waiting for the ball. They received the ball diagonally on the opposite side and balanced their body weight on the opposite foot to the one used for playing the ball. 4)Alternating reception with the outside of the foot and playing with the inside of the foot: Athletes stood in pairs at an 8-meter distance, approaching the ball with low skips. They shifted their body weight while receiving the ball with the outside of the foot and playing it with the inside of the foot. 5)Receiving with the sole and playing with the same foot: Athletes were in pairs at an 8-meter distance, executing low skips while waiting for the ball. They received the ball with the dominant foot in front of their body and played it with the same foot using the inside of the foot. 6)Receiving with the entire sole and playing with the entire sole: Athletes stood 8 meters apart, approaching the ball with low skips. They received the ball with the entire sole of one foot and played it with the same foot using the entire sole. Each exercise was performed three times for 30 seconds, followed by a 15-second break. After each exercise, there was a brief description of the next exercise.

RESULTS and DISCUSION

Table 1 displays the values (mean, standard deviation) achieved by both groups in the initial and final measurements.

Table 1. Results of Initial and Final Measurements in Both Groups of Football Players

	Experimental Group (Basic Coordination Training)		Control Group (Specific Coordination Training)	
Variable	**Initial Measurement AS±SD (min-max)**	**Final Measurement AS±SD (min-max)**	**Initial Measurement AS±SD (min-max)**	**Final Measurement AS±SD (min-max)**
Zig-zag ball control test	**9,46±0,46** 8,5-10,77	**8,36±0,68** 7,43-9,63	**9,39±0,50** 8,55-10,30	**7,96±0,43** 7,32-8,78
Loughborough passing test	**66,26±9,31** 46,39-81,2	**58,19±6,46** 43,6-68,01	**66,51±3,92** 60,98-73,82	**58,06±7,99** 38,51-70,70

Tables 2, 3, 4 and 5 show the results of the analysis of variance for repeated measurements in the tests "Zig-zag ball control test" and "Loughborough passing test".

Table 2. ANOVA for Repeated Measurements in the "Zig-zag Ball Control Test"

	SS	Degrees of Freedom	MS	F	p
Intercept	3091,443	1	3091,443	5263,193	0,000000
GROUP	0,545	1	0,545	0,928	0,348086
Error (Within)	10,573	18	0,587		
Time	15,964	1	15,964	256,945	0,000000
Time*Group	0,248	1	0,248	3,993	0,061040
Error (Within)	1,118	18	0,062		

Table 3. Bonferroni Post-hoc Test for the "Zig-zag Ball Control Test"

Cell No.	Bonferroni test; variable DV_1 (List1 in rez) Probabilities for Post Hoc Tests Error: Between; Within; Pooled MS = ,32475, df = 21,766					
	GROUP	Time	{1} 9,4610	{2} 8,3550	{3} 9,3850	{4} 7,9640
1	1	ZZi		0,000000	1,000000	0,000041
2	1	ZZf	0,000000		0,003328	0,836310
3	2	ZZi	1,000000	0,003328		0,000000
4	2	ZZf	0,000041	0,836310	0,000000	

Table 4. *ANOVA for Repeated Measurements in the "Loughborough Passing Test"*

Effect	SS	Degrees of Freedom	MS	F	p
Intercept	154486,3	1	154486,3	1768,856	0,000000
GROUP	25,7	1	25,7	0,295	0,593840
Error	1572,1	18	87,3		
Time	732,3	1	732,3	41,893	0,000004

TIME*GROUP	6,3	1	6,3	0,361	0,555385
Error	314,6	18	17,5		

Table 5. *Bonferroni Post-hoc Test for the "Loughborough Passing Test"*

Cell No.	Bonferroni test; variable DV_1 (List1 in rez) Probabilities for Post Hoc Tests Error: Between; Within; Pooled MS = 52,409, df = 24,928					
	GROUP	TIME	{1} 66,830	{2} 59,067	{3} 66,020	{4} 56,668
1	1	LTDi		0,003594	1,000000	0,025950
2	1	LTDf	0,003594		0,249955	1,000000
3	2	LTDi	1,000000	0,249955		0,000555
4	2	LTDf	0,025950	1,000000	0,000555	

The results of the Analysis of Variance for repeated measures and the Bonferroni post-hoc test show that both groups improved in the "Zig-zag ball dribbling test" and the "Loughborough passing test for young soccer players" under the influence of a four-week basic and specific training program. However, no differences were found between the groups that could be attributed to the differential characteristics of the training programs. Based on these results, it can be concluded that both basic and specific coordination programs are equally effective in developing specific coordination and motor skills in young soccer players. This research yielded positive changes in specific coordination abilities and agility, which can be attributed to the coordination training program. These results align with the studies conducted by Zago and colleagues (2016) and Frikha and colleagues (2017), which concluded that specific soccer performance can be improved through conditioning training with a focus on coordination. Motor experience resulting from a high diversity of skills is an essential factor for the ability to learn quickly and coordinate movements effectively (Bompa, 2000). Milanović (1997) defined coordination as the management of one's own body, characterized by fast and precise execution of complex motor tasks. While many believe that coordination is largely genetically predetermined (Šolaja, Petrović and Šolaja 2011), this research demonstrates that it can be enhanced when its development begins in childhood. This study shows that it is possible to develop coordination in young soccer players through both basic and specific coordination and agility programs. In the earliest stages, priority should be given to basic activities that ensure comprehensive, versatile preparation for athletes, which can also be applied in other sports and activities in free time and daily life (Karamatić, Vuljanić and Peršun 2011). The primary limitation of this research is the short duration of the program, so further studies with longer coordination training and expanded sets of tests for fundamental motor skills are needed. Additional research is required to determine if there are differences in fundamental motor skills and abilities between these two training programs. The preference was given to the basic training program in this study, making it the experimental group, as children in this age group should be exposed to a broader range of activities and programs to better develop fundamental skills that will aid

them in mastering specific sports abilities (Ribarić and Đurić 2011). According to Zago, Giuriola, and Sforza (2016), specific soccer performance is enhanced through conditioning training with an emphasis on coordination. According to Milanović (2013), coordination and speed development can be influenced up to the age of 14, with minimal improvement in later periods. Therefore, it is crucial to implement a program that will have the greatest impact on the development of these skills during the most sensitive phases. During puberty, it becomes increasingly challenging to acquire more complex motor skills due to unfavorable relationships between morphological dimensions and coordination, but it is still important to emphasize the stimulation of coordination, speed, flexibility, and agility (Neljak, 2013).

CONCLUSION

The aim of this study was to determine the effects of coordination training on specific technical performance (specific motor skills of dribbling and passing the ball) and specific coordination abilities in young soccer players. Additionally, it aimed to identify if there was a statistically significant difference between the Experimental Group, which underwent basic coordination training, and the Control Group, which underwent specific coordination training. The training program lasted for four weeks, including 12 sessions lasting 45 minutes each. Statistical analysis revealed that the results of the final tests were better compared to the initial tests, and there was a statistically significant difference between the initial and final measurements within each group in both the "Zig-zag ball dribbling test" and the "Loughborough passing test for young soccer players." Furthermore, the Bonferroni post-hoc test indicated that there was no statistically significant difference attributable to the different training programs between the Experimental Group that underwent basic coordination training and the Control Group that underwent specific coordination training in either of the tests. In conclusion, during this developmental stage, it is crucial to conduct training programs that focus on both basic and sport-specific coordination to enhance coordination abilities.

REFERENCES

1. Bompa, T. (2000). *Cjelokupan trening za mlade pobjednike.* Zagreb: Hrvatski košarkaški savez, Udruga hrvatskih košarkaških trenera.
2. Bekris, E., Gissis, I., Kounalakis, S. (2018). *The dribbling agility test as a potencial tool for evaluating the dribbling skill in young soccer players.* Sport medicine, 26:4, 425-435.
3. Bompa, T. (2000). *Periodizacija: Teorija i metodologija treninga*. Zagreb: Hrvatski košarkaški savez, Udruga hrvatskih košarkaških trenera.
4. Dujmović, P. (2000). *Škola nogometa.* Zagreb: Zagrebački nogometni savez.
5. Erceg, M., Rađa, A., i Sporiš, G. (2018). *Razvoj nogometaša: Antropološki status nogometaša tijekom razvojnih faza.* Zagreb.
6. Gardašević, J., Georgiev, G., i Bjelica, D. (2012). *Qualitative changes od basic motor abilities after completing a six-week training programme* (str. 70-74). Acta kinesiologica. Dostupno na https://pdfs.semanticscholar.org/74a6/714666ea0c872d2f7e16fef490f2313b3f60.pdf

7. Karamatić, L., Vuljanić, A. i Peršun, J. (2011). *Trening koordinacije djece i mladih.* Kondicijska priprema sportaša 2011. Kineziološki Fakultet, Sveučilište u Zagrebu, Udruga kondicijskih trenera Hrvatske.
8. Le Moal, E., Rue, O., Ajmol, A, Abderrahman, A.B., Hammami, M.A., Ounis, O.B., ... Zouhal, H.(2014). *Validation of the Loughborough Soccer Passing Test in Young Soccer Players.* Journal of Strength and Conditioning Research.
9. Malacko, J. (1991). *Osnove sportskog treninga.* Novi Sad
10. Milanović, D. (1997). *Osnove statistike i kineziometrije: Priručnik za sportske trenere* (str. 480-603). Zagreb. Fakultet za fizičku kulturu.
11. Milanović, D. (2013). *Teorija treninga, Kineziologija sporta.* Zagreb.
12. Neljak, B. (2013). *Kineziološka metodika u osnovnom i srednjem školstvu.* Zagreb: Gopal d.o.o.
13. Ribarić, P. i Đurić, V. (2011). *Razvoj koordinacije djeteta.* Kondicijska priprema sportaša 2011. Kineziološki Fakultet, Sveučilište u Zagrebu, Udruga kondicijskih trenera Hrvatske.
14. Šolaja, M., Petrović, M. i Šolaja, A., (2011). *Prikaz vježbi na podnim ljestvama za razvoj koordinacije.* Kondicijska priprema sportaša 2011. Kineziološki Fakultet, Sveučilište u Zagrebu, Udruga kondicijskih trenera Hrvatske.
15. Vučetić, V., Sporiš, G. (2016). *Dijagnostika (*str. 115-122). Zagreb: Školska knjiga.
16. Zago, M., Giuriola, M. i Sporza, C. (2016). *Effects of a combined technique and agility program on tourh soccer players skills.* Internation journal of Sports Science & Coaching, 10/01/2016, Vol.11(5), str. 710-720; Sage Publications.
17. Zatsiorsky, V.M. (2002). *Kinetics of human motion.* Human kinetics.
18. Zoranjić, J., Bašalić, A. i Čović, N (2011). *Razvoj koordinacije kod djece nogometaša.* Kondicijska priprema sportaša 2011. Kineziološki Fakultet, Sveučilište u Zagrebu, Udruga kondicijskih trenera Hrvatske

The Difference in Physical Activity of Students with Regular Development and Students with Developmental Disabilities

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ABSTRACT.

The term children with developmental disabilities includes children with congenital and acquired conditions of the organism. Each child must be approached according to their needs, because their developmental difficulties can be caused by various factors such as genetic predisposition, neurological and biological factors, and trauma. Unlike children with normal development, children with developmental disabilities require special care, especially when it comes to physical activity and motivating the child in order to encourage a healthy lifestyle. The aim of this paper is to determine the difference in physical activity between students with regular development in elementary schools in the city of Osijek and students with developmental disabilities from the Center for Autism Osijek and the Center for Education "Ivan Štark" in Osijek. The research was conducted with a total of 1295 students, of which 1242 were children with normal development and 53 students with developmental disabilities. In the framework of this research, the IPAQ questionnaire designed to determine the level of physical activity of the respondents in the last seven days was used. The aim of the research was to clarify the extent to which developmental differences affect physical activity patterns. The questionnaire is focused on different types of activities that include playing sports, dancing or games that require intense physical effort such as running, climbing, jumping, cycling and the like. This aspect of the research is crucial, given that various indicators of physical condition and health, as well as the quality of life of the respondents in general, can be determined through the mentioned activities. The research results indicate significant differences in the levels of physical activity between the two groups. The research has useful information for all professionals who aim to promote physical activity for all students. In addition, by encouraging more equitable and accessible access to physical activity, competent professionals can contribute to the general well-being and social integration of students with different developmental needs. By recognizing variations in engaging in physical activity, interventions can be designed to respond to the specific needs of students with developmental disabilities and ultimately foster a fairer and more accessible environment for participation in physical activity.

Keywords: children with developmental disabilities, developmental differences, health, physical.

INTRODUCTION

According to the World Health Organization (WHO, 2022), physical activity is defined as the result of higher energy consumption caused by the action of skeletal muscles compared to the resting state, which includes daily physical activities such as playing, physical work, recreational activities. Namely, physical activity is often equated with physical exercise that is planned, programmed, structured with the aim of improving and maintaining motor and functional abilities. In their work, Mišigoj-Duraković and Duraković (2014) state that children neglect physical activity due to the often-prevalent sedentary lifestyle. The importance of acquiring healthy habits is the basis for the prevention of cardiovascular diseases, obesity, and in addition, physical activity promotes a healthy lifestyle, including children with disabilities. The term children with developmental disabilities refers to children with congenital and acquired conditions of the organism, and they require special care and a professional approach, thus enabling appropriate socialization, upbringing and life of the child (Mikas and Roudi, 2012). Each child is unique and difficulties may vary, so each child must be approached according to their needs. Due to congenital and acquired defects, we categorize developmental difficulties according to the type and degree of damage that can be caused by various factors such as genetic predisposition, neurological and biological factors, trauma (Mikas and Roudi, 2012). Children with developmental disabilities need multidisciplinary guidance in rehabilitation because, in addition to primary damage, they have multiple diseases due to disorders of the central nervous system (Bulić et al., 2012). Multidisciplinary management represents cooperation between several experts from different professions, which is based on a holistic approach to the diet. According to the holistic approach, the child is placed at the center of the event and is viewed as a whole, including all the child's needs. Researchers have confirmed lower results in people with intellectual disabilities in tests to assess strength, flexibility, endurance, coordination, cardiovascular endurance and in general physical activity compared to peers with regular development (Chien et al., 2017). Also, Hartman et al. (2015) confirm in their research that children with developmental disabilities have significantly lower results in almost all specific motor skills compared to children with normal development. In recent literature, Jin et al. (2023) prove with their research that a potential reason for the low level of participation in physical activity in children with developmental disabilities is closely related to delayed motor skills or a lack of motor skills compared to their normally developing peers. Such results are associated with limited mental abilities, short attention span, disturbances in motor development and lack of motivation and a sedentary lifestyle (Golubović et al., 2012).

METHODS

The aim of this paper is to determine the difference in physical activity between students with regular development in primary schools in the city of Osijek and students with developmental disabilities from the Center for Autism Osijek and the Center for Education "Ivan Štark" in Osijek.

Based on the established goal, the hypothesis was set:

H1: Students with regular development will have a higher level of physical activity compared to students with developmental disabilities.

The sample of respondents consisted of students with regular development and students with developmental disabilities. Table 1 shows

the total number of students who answered the survey question. 1242 of them were students with regular development and 53 of them were students with developmental difficulties.

Table 1. Number of respondents who answered the survey question

		Number of respondents	Percentage	Cumulative frequencies
Variables	Students of regular development	1242	95.9	95.9
	Students with developmental disabilities	53	4.1	100.0
	In total	1295	100.0	

As part of this research, a questionnaire designed to determine the level of physical activity of the respondents in the last seven days was used. Respondents completed the short version of the International Physical Activity Questionnaire (IPAQ). For students with developmental disabilities, the survey was completed by the parents due to the impossibility of understanding it. The questionnaire is focused on different types of activities that include playing sports, dancing or games that require intense physical effort such as running, climbing, jumping, cycling and the like. This aspect of the research is crucial, given that various indicators of physical condition and health, as well as the quality of life of the respondents in general, can be determined through the mentioned activities. It is worth noting that the questionnaire is not designed as a test, but as a tool for collecting information. There are no "correct" or "incorrect" answers, and the emphasis is on the honesty of the respondents. Each answer is valuable, because each provides an insight into the physical activities of the respondents. The anonymity of the respondents is guaranteed, and thus the reliability of the results is ensured.

Data analysis was performed using the IBM SPSS Statistics software package. For the results obtained for each variable among the respondents, the following descriptive statistical indicators were calculated: arithmetic average (Mean), median (Median), lowest value (Min), highest value (Max), standard deviation (Std. Dev.). To determine differences between groups, a non-parametric t-test for independent samples is used - the Mann Whitney U test, and the effect size is calculated using the formula $r = Z / \sqrt{N}$.

RESULTS and DISCUSION

According to the descriptive indicators, we can conclude that the students think that they are most active during the TZK classes (Med=5; AS=4.40). Furthermore, in their free time, they mostly engage in cycling (Med=3; AS=2.96), running (Med=3; AS=2.94). and dancing and sports games (Med=3; AS=2.85). Other activities are very rarely represented.

There is a statistically significant difference between students with regular development and students with developmental disabilities ($p < 0.05$) in physical activity in their free time in the last seven days (last week) who played skipping, shown in table 2. Students with regular development played more skipping (Mean Rank = 657.88) than students with developmental disabilities (Mean Rank = 404.34). The effect size ($r = Z / \sqrt{N}$) is small (0.13).

Table 2: Mann Whitney U test by activities

Activity	Rank Sum Students of regular development	Rank Sum Students with developmental disabilities	U	Z	P
Preskakanje	656.96	425.89	21141.00	-4.75	0.00
Roller skating	654.53	482.96	24166.00	-4.04	0.00
Lovice	657.88	404.34	19999.00	-5.00	0.00
Walking	652.54	529.41	26627.50	-2.41	0.016
Riding a bicycle	663.36	276.04	13199.00	-7.57	0.00
Jogging	662.80	289.15	13894.00	-7.29	0.00
Aerobic	651.51	553.51	27905.00	-2.90	0.04
activities during PE classes	666.69	198.19	9073.00	-10.44	0.00
participation in sports, dance or games	659.20	373.57	18368.00	-5.59	0.00
describing oneself in participation in physical activities	658.34	393.77	19439.00	-5.17	0.00
football	658.67	385.95	19024.50	-5.51	0.00
badminton	654.02	494.84	24795.5	-3.989	0.00
skating	653.50	507.00	25440.00	-3.88	0.00
volleyball	658.82	382.49	18841.00	-5.78	0.00
basketball	657.51	413.05	20460.50	-5.20	0.00
ice skating	650.08	587.00	29680.00	-2.38	0.022
participation in other physical activities	654.57	481.98	24114.00	-3.47	0.00

The questionnaire that served the purpose of the research was a tool for collecting information, in this research not all differences were accurately confirmed due to factors that greatly influenced the results of the research. Uncollected data about the participants in this work are: gender, age and level of developmental disability, which would significantly contribute to the research. In the paper, significant differences in physical activity were determined, which is why children with regular development surpass children with developmental disabilities. Accordingly, there is a significantly larger number of samples of regular development students, which emphasizes the existence of an imbalance between the groups in the research. However, the results showed that there is no statistically significant difference in physical activity when sports such as: baseball, dance, street hockey, indoor hockey, ice hockey, cross-country skiing, swimming, rowing are questioned. Most of the listed activities are not represented in the city of Osijek and this is the reason for the lack of difference, while swimming is the only organized activity in the city of Osijek for children with disabilities. Swimming provides various benefits to children with developmental disabilities. Fragala-Pinkham (2008) in her research "Group

aquatic aerobic exercise for children with disabilities" states that swimming affects physical fitness, sensory integration, improvement of motor skills, social interaction, confidence and self-esteem of the child, cognitive advantages, regulation of emotions, fun and recreation and has therapeutic effects. Buljubašić-Kuzmanović (2017) in his review article "The impact of therapeutic riding on the social development of children with developmental disabilities" states that children with mild developmental disabilities have lower results in locomotor skills compared to children with borderline disabilities, while children with a lower level difficulty achieve better results in coordination tests. Furthermore, Glumbić et al. (2012) state that researchers have confirmed lower results in tests for assessing strength, coordination, muscular endurance, flexibility and functional abilities in people with developmental disabilities. Also, Hartman et al. (2011) state that an insufficient level of physical activity can be associated with a short attention span, mental limitations, lack of motivation and a sedentary lifestyle without encouraging caregivers to create healthy lifestyle habits.

CONCLUSION

The research results indicate significant differences in the levels of physical activity between the two groups. The results obtained from this research confirmed the hypothesis that students with normal development will have a higher level of physical activity compared to children with developmental disabilities. In the past, children with developmental disabilities experienced a discriminatory approach that caused unwanted reactions both for them and for the entire environment. Through the development of educational programs, professional support and educational adaptation are the basis of the programmed upbringing and education of children with developmental disabilities. A competent teacher should encourage physical activity and, with an individual plan and program, direct the child to participate in the PE class, because any child with developmental disabilities who does not have additional impairments can be integrated into the regular program. As children go through the period of the modern era, there are more and more misconceptions about the importance of exercise and they devote themselves more to sedentary activities, which has significant implications. Inclusive education of children with developmental disabilities encourages the creation of a shift within the educational paradigm. Such developments underscore the value placed on recognizing the uniqueness of each child, sharing common activities in everyday life, and harnessing the innate potential of each individual for the collective enhancement of personal and broader well-being. The most important part of this evolution are educators and guardians who have a key role in the educational story and guiding them on the right path, i.e. creating healthy habits and a healthy lifestyle. By embracing variety and physical activity, the child's future is illuminated where they can express their potential and develop additional motivation and self-confidence to strive to be better in the physical activities in which they find themselves.

REFERENCES

1. Bulić, D., Nikolić., B. Oreb, I. J. (2012). Angažman majki djece s teškoćama u razvoju u svakodnevnim aktivnostima. Hrvatska revija za rehabilitacijska istraživanja, 48(2), 1-12.
2. Buljubašić-Kuzmanović, V. (2017). Utjecaj terapijskog jahanja na socijalni razvoj djece s

teškoćama u razvoju. Školski vjesnik, 66(2), 255-269.
3. Chien, C. W., Copley, J. i Rodger, S. (2017). Differences in patterns of physical participation in recrational activities between children with and without intellectual and developmental disability. Research in Developmental Disabilities, 67, 9-18.
4. Duraković., Z. i Mišigoj-Duraković, M. (2014). Zdravstveni aspekti tjelesne aktivnosti za djecu, učenike i mladež s posebnim potrebama. U: Findak, V. (ur.), Zbornik radova 23. ljetne škole kineziologa „Kineziološke aktivnosti i sadržaji za djecu, učenike i mladež s teškoćama u razvoju i ponašanju te za osobe s invaliditetom“ (str. 71-76). Zagreb: Hrvatski kineziološki savez.
5. Fragala-Pinkham, M., Haley, S. M. i O'Neil, M. E. (2008). Group aquatic aerobic exercise for children with disabilities. Developmental medicine and children neurology, 50(11), 822-827.
6. Glumbić, N., Golubović, B., Golubović, Š. i Maksimović, J. (2012). Effects of exercise on physical fitness in children with intellectual disability. Research in Developmental Disabilitties, 33(2), 608-614.
7. Hartman, E., Smith, J., Visscher, C. i Westendorp, M. (2015). Development of physical fitness in children with intellectual disabilities. Journal of Intellectual Disability Research, 59(5), 439-449.
8. Hartman, E., Houwen S., Visscher, C. i Westendorp, M. (2011). Are gross motor skills and sports participation related in children with intellectual disabilities?. Research in developmental disabilities, 32(3), 1147-1153.
9. Jin, J. i Lee, H. K. (2023). The effect of a virtual reality exergame on motor skills and physical activity levels of children with a developmental disability. Research in developmental disabilities, 132, 104386.
10. Mikas, D. i Roudi, B. (2012). Socijalizacija djece s teškoćama u razvoju u ustanovama predškolskog odgoja. Paediatr Croat, 56(1), 207-214.
11. World Health Organization: WHO. (2022). Physical activity. https://www.who.int/news-room/fact-sheets/detail/physical-activity

Impact of Sports on Social Anxiety and School Success in Primary School Children

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ABSTRACT

Sport is an extremely important activity that is supposed to have significant effects on the physical, mental and social development of millions of children who engage in it. The impact on the growth and development of children has been confirmed through a large number of studies that give us insight into how positively sport influences youth in the field of mental and physical health. Determining the presence of a connection between playing sports, better cognitive development and social skillsThe research was conducted in the elementary school "Karađorđe" in the period from 12.12.2020. to 21.12.2020. Teachers of the second-grade students of this primary school participated in this research. The main tool of the research was the Teachers report form-ASEBA questionnaire. The research involved 4 teachers of the second-grade class who filled out questionnaires for 110 students. The sample consisted of 52.7% girls. 67.3% are engaged in sports. The share of children who required additional work with a teacher was 6.4%, and 5.5% had a disability or illness (physical or mental). The obtained results showed the level of significance ($p < 0.05$) in school success, anxiety-depressive characteristics ($p = 0.002$), aggression ($p = 0.027$), attention problems ($p = 0.00$) and opinion ($p = 0.004$), delinquency ($p = 0.00$), withdrawal ($p = 0.00$) and various social problems ($p = 0.00$)**.** Sport as a source of physical activity positively affects the growth and development of children, developing their social skills and cognitive abilities.

Key words: social skills, cognitive development, mental health, physical health, physical activity

INTRODUCTION

Sport includes all forms of physical activity that aim to improve physical fitness and mental health, form social relationships or achieve results in competitions of all levels (1). Involvement in sports is considered to have important consequences for children's physical, psychological and social health (2). Health benefits that can be associated with physical activity during childhood and adolescence can lower possibility of developing metabolic syndrome or obesity, skeletal and mental health problems, and a reduce risk of chronic diseases such as heart disease or type 2 diabetes (3). Organized sports activities for children and adolescents can have a great impact on psychosocial advantages like self-confidence and social skills. Sports gives children the opportunity to socialize with their peers, teaches them how to work in a team, self-discipline and also how to behave according to social rules, develops their negotiation skills, decision-making skills and contributes to

gaining self-confidence for independent decision-making (3).

Recent research has shown that physical activity can also have an impact on cognitive skills and memory. Physiological mechanisms, such as increased cerebral blood flow, changes in brain neurotransmitters, structural changes in the central nervous system, and modified levels of excitation are based on physical changes in the body caused by exercise. Learning and developmental mechanisms indicate that movement and physical activity can provide learning experiences that help and may even be necessary for proper cognitive development (4). Exercise and physical activity improve circulation, blood flow to the brain and raise levels of noradrenaline and endorphins. All of the above has an effect on reducing stress, improving mood swings, and producing a feeling of relaxation after exercise, which can influence the improvement of academic achievement (5).

Conducted studies show a positive association between fitness and academic performance among children and adolescents. Cardiorespiratory fitness affects brain plasticity and is associated with better cognitive abilities, increased brain function and improved memory (6). fMRI confirmed that children who are regularly participate in sports can activate the frontal and parietal cortices much faster than childeren who do not, which are essential for monitoring, maintenance, and higher-level cognitive control strategies important for academic success (7).

The impact of physical activity can also be seen on a person's social and psychological functioning through better psychological adjustment, less frequent episodes of depression and antisocial behavior, as well as a better relationship with peers (8). Sports encourages positive development in young people because it focuses on the good sides and abilities of the each individual instead of problems, risky behaviors and negative outcomes (9).

Given the impact of sports on children's lives, this study was conducted to compare to what extent does the difference show in the physical, psychological and social functioning of elementary-school-aged children who are actively involved in sports and children who are not. The goal of the study was to determine whether sports plays a significant role in the growth and development of children, in other words, how much does it help in overcoming social anxiety and how much does it contribute to academic success.

METHODS

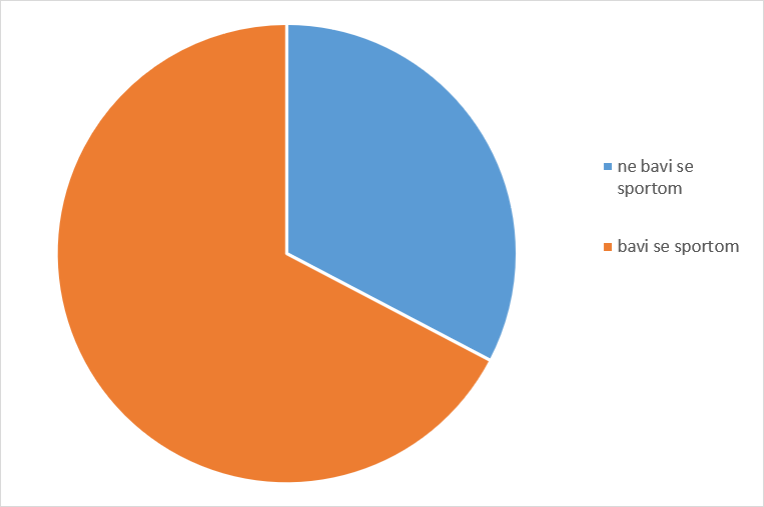
The research for this study was conducted at the elementary school "Karađorđe" using a questionnaire filled by all the teachers of second grade classes. Every teacher has filled a personalized questionnaire for every child in their class. A total of 110 questionnaires were collected. The research was done from 12-21 of descember 2020. The questionnaire was anonymous and classifed on whether the child plays sports. Consent toconducting the research was given by the school director and the school board. Teacher Report questionnaire (TRF-ASEBA) assesses emotional problems, behavioral problems and social skills. It gives results for 8 narrowly defined scales or syndromes: reclusiveness, somatic problems, anxiety/depression, social problems, attention disorder, thought disorder, delinquency and aggression. It evaluates adaptive functioning and academic performance. The questionnaire

is filled by teachers or school staff who works with the student or has been following his/hers behavior for more than two months. TRF-ASEBA assesses students level of depression, anxiety and psychosocial functioning (10).

It also estimates adaptive functioning in academic tasks with four adaptive characteristics (dedication to schoolwork, appropriate behavior at school, ability to assimilate what has been learned and general satisfaction). Grades for the child's success at school in various subjects are evaluated on a scale from 1 (below average) to 4 (above average). Four adaptive characteristics are assessed on a scale from 1 (much less) to 5 (much more). In the questionnaire, there are open- and closed-type questiones. Closed type questions include 113 questions that are evaluated on the basis of a Likert scale (0-incorrect, 1-approximately or sometimes true and 2-true or often true). Open-ended questions refer to the teacher's opinion about the student and includes what the teacher is most concerned about in regars to the student, the best characteristics of the student and an additional comment regarding likes, behavior or student's potential to achieve something. Descriptive statistics were used for processing data. Frequencies and percentages for categorical variables, and measures of central tendency (arithmetic mean, standard deviation) were used. Welch's t-test was used to compare differences between groups, as an alternative to analysis of variance that is more robust to deviations of the distribution of continuous variables from normality.

RESULTS and DISSCUSION

110 students of the second grade of elementary school were included in this research. The sample consisted of 47.3% boys. In the conducted research, the main parameter on the basis of which we observed and compared other variables to was students engagement in sports. In the examined group, 67.3% of children practice some kind of sport.



Graph 1: Distribution of respondents in correlation to their engagement in sports

From the total group of respondents, we had 6.4% of children who require additional work with the teacher or have some special needs (autism). 5.5% had some disability or illness (physical or mental). The largest number of

students were at the average level in mathematics (62.7%), Serbian (69.1%), foreign language (73.6%), natural science (71.8%), art (76.4%) and musical education (79.1%).

Table 1. Succues rate of respondents for each subject Bellow average

	Little bellow average	Average	Above average
Mathematich	2,7%	11,8%	62,7%
Serbian language	2,7%	10,0%	69,1%
Foreign language	0,9%	5,5%	73,6%
Natural science	1,8%	7,3%	71,8%
Musical education	2,7%	0,9%	79,1%
Art	0,9%	1,8%	76,4%

Adaptive characteristics assessment has shown that 54.5% are average in terms of commitment to school work, 50.9% are behaving averagely adequate, 54.5% are average in adopting what they have learned and 49.1% are averagely generaly satisfied.

Table 2. Assesment od adaptive characteristics in repondents

	Is he/she behaving properly acorrding to social rules?	How much does the student adopt what they have learned?	How much is he/she generally satisfied?
A lot less	4,5%	2,7%	2,7%
Little bit less	12,7%	8,2%	10%
Average	54,7%	50,9%	54,5%
Little bit more than average	23,6%	27,3%	19,1%
A lot more than average	4,5%	10,9%	13,6%

A difference in school performance between children who are engaged in sports and those who are not was confirmed. Results have shown that children who play sports were better in school, especially in: mathematics (p=0.001), natural science (p=0.00), Serbian (p=0.00) and a foreign language (p=0.00). Children who play sports were adopting information more efficiantly and applying the learned knowledge easier (p=0.00) in comparecent to children who are not engaging in sports. The child's behavior and general satisfaction in his/hers environment also shows better results in athletes (p=0.00). Children who train regularly show less anxiety-depressive characteristics (p=0.002), aggression (p=0.027), attention problems(p=0.00) and thinking problems (p=0.004), delinquency (p=0.00), (p=0.00) and various social problems (p=0.00). There is a significant difference especially in the maintaining attention on the given tasks, delinquency, reclusiveness and various social

problems, which shows the positive impact of sports on socialization, the child's behavior, as well as the acceptance and respect of social norms. Regarding gender differences in relation to sports in academic success and learning acquisition, girls performed better than boys. In every other interaction, gender differences were not statistically significant.

Part of the questionnaire descriptively assessed what worries the teacher most about a student and what is the best characteristic of that student. Teachers had the opportunity to give their comments on the work and behavior of the students. The results related to children who do not participate in sports were generally reduced to the fact that these children are more withdrawn, dissatisfied and irresponsible. There is also a tendency among these children to enter into conflicts with others more often or to not tell the truth when in contact with the teacher, they have difficulty in cooperating and communicating with their peers and teachers. When commenting on students who do not train, teachers more often wrote "that they can do more" than what they are currently showing at the academic level. Regarding children who play sports, the answer that was repeated the most was, setting goals too high" which puts added pressure on the student. Additional comments did not provide responses that would indicate the worrisome behavior of these students.

Throughout this research we were comparing how big is the impact of sports on childrens well-being and social adaptation. Comparing athletes and non athletes with TRF-ASEBA questionnaire we came to the conclusion that sporsts plays a great part in academic success, anxiety and social problems. It was comfirmed that sports has a positive impact on psycological and social poblems. Results show correlation with the assumptions that sport has a significant impact on the life and maturation of those who engage in it. Previous research of this type, conducted on much larger samples, also shows the influence of sports, ie. physical fitness on academic success in children and adolescents (11).

The results of various studies show that students who regularly engage in sports have better success in school, more positive perceptions of family support, community support and safety at school compared, to their peers who do not have regular physical activity (12). This is supported by the results of this study, children who do sports have better academic success in school in all subjects and learn more efficiently ($p<0.05$). Participating in sports helps socially anxious children be in situation that includes them and let s them feel apart of the team without any pressure to over socialaze if they are not comfrotable. It supports and teaches children that feel scared, to overcome their anxiety trough physical activity and shows them a different form od socialization where they do not feel intimidated (13).

Involvement in a certain sport in general represents a positive factor in the physical and mental development of a child, which has been confirmed in various studies and research (13). Social problems, anxiety-depressive characteristics and reclusiveness are significantly lower in children who play sports, as confirmed by the results of our study. Also, the difference in satisfaction and good mood (assessment how happy the child is) was shown. Children who train have greater satisfaction and are happier than children who do not play sports. Nevertheless, in certain

studies, the results did not confirm a significant relationship between the impact of sport on cognitive development (14). Some studies showed that sports does not have a negative impact on development, but that in certain cases it does not show the expected level of significance (14,15). Regardless, in this research, the connection between cognitive development and engaging in sports was shown. A significant difference was observed between the two groups of respondents, where children who play sports have shown better progres on a cognitive level.

Even if we get favorable results through various studies with the same or similar topics, sometimes we lack clear and consistent conclusions based on the results. Analyzes of the results often do not consider the role of other factors that influences the persons cognition and social behavior. Also, the tests that measure academic success differ from study to study and this can significantly influence the differences in the interpretation of research results (16). Physical activity may have specific effects on children's cognitive functions instead of a general effect and this may explain the lack of agreement between different studies (16). Consequenty, tests that focus on certain aspects of academic performance are much more informative than tests that cover a wide range of academic performance (16). Unfortunately, the lack of this type of research is that the studies that best prove the positive correlation of sports, cognitive and social skills would require monitoring children for a certain period of time, for example through 8 years of elementary school.

The main goal of this research was to show the positive impact of sports on success in school and the effect on social problems and anxiety. The results of the conducted research confirmed the connection between cognitive development, social behavior and active sports. Sports can be a positive factor in a child's mental development, as well as an effective way to overcome social problems that children may encounter in their daily lives.

CONCLUSION

Sport is one of the tools that can be used to encourage children to develope cognition and social adaptation in a healthy way. It provides children with the opportunity to acquire social skills, helps in overcoming anxiety and gives a sense of being apart of a group. Playing sports helps in the development of cognitive functions that can result in better academic performance and clearer understanding of what has been learned. Promoting and supporting sports activities contributes to a healthier way of life for all children in every sense. Because of this, schools and the social environment should provide children with the availability of sports fields, organize sports activities, support and allow sports clubs to hold organized training sessions at schools. Sports should support children in a mental and physical sense and cultivate positive traits and abilities of individuals, thus enabling healthy development of body and spirit.

REFERENCES

1. Hiremath C. Impact of sports on mental health. *Internat J Physi Nutri Phys Edu*, 2019; SP1: 14-18.
2. Hedstrom R, Gould D. Research in youth sports: Critical issues status. Michigan State University, Michigan, 2004; 1-42
3. Vella SA, Schranz NK, Davern M, Hardy LL, Hills AP, Morgan PJ,et al. The contribution of organised sports to physical activity in Australia: Results and directions from the active healthy kids Australia 2014 report card on physical activity for children and young people. *J Sci Med Sport*, 2016; 19;407–412
4. Sibley BA, Etnier JL. The relationship between physical activity and cognition in children: a meta-analysis. *Pedi Exer Sci*, 2003; 15(3):243–256.
5. Taras H. Physical activity and student performance at school. *J Sch Health 75*, 2005; 75(6):214-218
6. Sardinha LB, Marques A, Martins S, Palmeira A, Munderico C. Fittness, fatness and academic performance in seventh-grade elementary school students. *BMC Pediatrics*, 2014; 14:176
7. Chaddok-Heyman L, Erickson KI, Voss MW, et al. The effects of physical activity on functional MRI activation associated with cognitive control in children: A randomized controlled intervention. *Biol Psychol*, 2012; 89(1): 260-268
8. Van Boekel M, Bulut O, Stanke L, Palma Zamora JR, Jang Y, Kang Y, et al. Effects of participation in school sports on academic and social functioning. *J of App Develop Psyc*, 2016; 46:31-40
9. Taras H. Physical activity and student performance at school. *J Sch Health 75*, 2005; 75(6):214-218
10. Bordin IA, Rocha MM, Paula CS, Teixeira MCTV, Achenbach TM, Rescorla LA, et al. Child Behavior Checklist (CBCL), Youth Self-Report (YSR) and Teacher's Report Form (TRF): an overview of the development of the original and Brazilian versions. *Cad Saude Publica*, 2013; 29(1):13–28.
11. Sardinha LB, Marques A, Martins S, Palmeira A, Munderico C. Fittness, fatness and academic performance in seventh-grade elementary school students. *BMC Pediatrics*, 2014; 14:176
12. Van Boekel M, Bulut O, Stanke L, Palma Zamora JR, Jang Y, Kang Y, et al. Effects of participation in school sports on academic and social functioning. *J of App Develop Psyc*, 2016; 46:31-40
13. Dimech AS, Seiler R. Extra-curricular sport participation: a potential buffer against social anxiety symptoms in primary school children. *Psychol Sport Exerc*, 2011; 12:347–354

14. Rasberry CN, Lee SM, Robin L, Laris BA, Russell LA, Coyle KK, et al. The association between schoolbased physical activity, including physical education, and academic performance: a systematic review of the literature. *Prev Med*, 2011; 52:S10–S20
15. Yu CCW, Chan S, Cheng, F, Sung RYT, Hau K-T. Are physical activity and academic performance compatible? Academic achievement, conduct, physical activity and self-esteem of Hong Kong Chinese primary school children. *Educational Studies*, 2006; 32(4):311-341
16. Donnelly JE, Hillman CH, Castelli D, Etnier JL, Lee S, Tomporowski P, et al. Physical activity, fitness, cognitive function, and academic achievement in children: a systematic review. *Med Sci Sports Exerc*, 2016; 48:1197–1222