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SADRŽAJ

DEAR READER,

The research from the field of sports in this issue yields results from different sports branches, being conducted on different age categories. Papers founded on the results of research conducted under the COVID-19 pandemic conditions or related to the COVID-19 pandemic are present in this issue, and it is our belief that, in the following period, there will be more papers which will expose the stated topic. In each issue, we strive to publish new achievements which represent a requirement for the development of new technologies and processes dictating the efficacy of results which are an indicator of good work and progress. 18 papers from 12 countries were selected for this issue, and we are grateful to all authors who have sent their papers and dedicated themselves to conducting research. Just like in all other issues, we have not been able to publish all the papers that have been sent to our editorial office, and they will have to wait for the next issue. We rejoice in the fact that there is much interest in our journal, which confirms the attraction trend as a prerequisite for continuous work quality. Our reviewers and the Editorial Board have professionally edited this issue of the journal taking into account the standards and criteria important for the journal's referentiality. We truly hope that the results will help our readers in their work and be cited, which is the purpose and end goal of this journal.

The papers published in this issue belong to the fields of sports medicine, sports management and education, the training process and sports recreation, bringing forth new knowledge and values as a contribution to the development of sports science. The topic diversity used by authors from around the world is a benefit providing each reader with the opportunity to focus their interest on the needs in the scientific sphere.

As in all other issues, this issue contains papers which are the result of the research conducted by authors from different countries. An insight into the content of these papers clearly shows the relevance in the selected field of sports and a multidisciplinary quality and approach which we will prefer and promote in the upcoming period.
We would like to invite all of you, who follow our journal, to offer new research and open the areas which have so far been "closed" and did not receive the necessary attention so that, together, we could enrich the area of sports with new findings which will manage the changes. Our wish is to create a space for innovative research and support the authors who accept today's challenges so as to affect the changes which will build the future. We hope that, together, we will continue to create new values that enrich us and our environment.

Nihad Selimović, MD, MSc
Editor in chief

DRAGI ČITATELJU,

Istraživanja u oblasti sporta u ovom broju donose nam rezultate iz različitih sportskih grana, a rađena su na različitim uzrasnim kategorijama. Radovi autora koji su zasnovani na rezultatima istraživanja koja su provedena u uslovima pandemije COVID-19 ili se povezuju sa pandemijom COVID-19 nalaze se i u ovom broju, a vjerujemo da će naredni period ponuditi mnogo više radova koji će eksponirati navedenu temu.

U svakom broju nastojimo objaviti nova dostignuća koja su uslov za razvoj novih tehnologija i procesa od kojih zavisi uspješnost rezultata koji su pokazatelji dobrog rada i napredovanja.

Za ovaj broj je odabrano 18 radova iz 12 zemalja i zahvalni smo svim autorima koji šalju svoje radove i i koji su posvećeni istraživačkom radu. I u ovom broju nismo bili u mogućnosti objaviti sve radove koji su pristigli u našu redakciju i sačekati će objavu narednog broja. Raduje nas zainteresiranost za naš časopis čime potvrđujemo trend atraktivnosti što je preduslov za kontinuirani kvalitet rada. Naši recenzenti i Uredнički odbor su na vrlo profesionalan način uredili i ovaj broj časopisa vodeći računa o standardima i kriterijima koji su važni za referentnost časopisa. Iskreno se nadamo da će rezultati poslužiti čitateljima u njihovom radu i da će biti predmet citiranosti što i jeste svrha i krajnji cilj ovog časopisa. Radovi koji su objavljeni u ovom broju su iz područja sportske medicine, sportskog menadžmenta i obrazovanja, trenažnog procesa i sportske rekreacije te donose nova saznanja i vrijednosti kao doprinos unaprjeđenju sportske nauke. Raznovrsnost tematike koja nam dolazi od autora iz cijelog svijeta je benefit koji svakom čitatelju daje mogućnost da pronađe svoj interes pažnje i potreba u naučnoj sferi.
I u ovom broju imamo radove koji su nastali kao rezultat istraživanja više autora iz različitih zemalja. Uvidom u sadržaj tih radova jasno se pokazuje povezanost u odabranom području sporta i multidisciplinarni kvalitet i pristup koji ćemo i u narednom periodu preferirati i promovisati.

Pozivamo sve vas, koji pratite naš časopis, da nam ponudite nova istraživanja, da otvorimo do sada „zaključane" prostore koji nisu bili u centru pažnje i da svi zajedno obogatimo prostor sporta sa novim saznanjima koja će upravljati promjenama. Želimo da damo prostor inovativnim istraživanjima i da podržimo autore koji prihvataju izazove sadašnjeg vremena kako bi uticali na promjene koje će graditi budućnost. Nadamo se da ćemo zajedno i dalje stvarati nove vrijednosti koje obogaćuju i nas i naše okruženje.

Mr. sci. dr. Nihad Selimović
Glavni urednik

THE EFFECT OF HURDLE HOP TRAINING WITH THE 1:6 INTERVAL ON MUSCLE STRENGTH: VOLLEYBALL PLAYERS

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ABSTRACT

At this time, sport is one of the most important needs for the community, so it can be seen where people are doing sports activities. People already know that exercise is beneficial for health and fitness. Volleyball is one of the most popular sports in Indonesia. This study aims to determine the effect of obstacle course training at 1:6 intervals on leg muscle strength. This study was quasi-experimental, and the population in this study comprised all volleyball achievement coaching that could be done by 11 athletes. The instrument used is the JUMP-DF. Data analysis was conducted using a t-test. The test results show that there is a significant difference or effect of obstacle hop training using 1:6 interval training on the leg muscle strength of volleyball athletes, which is significant at 0.001 < 0.005. Therefore, obstacle hop training using 1:6 intervals is suitable to improve the performance of volleyball athletes.

Keywords: hurdle hops, interval training, leg muscle strength

INTRODUCTION

Nowadays, volleyball has become a sport in which physical strength as well as technical and tactical elements are used at the top level (Çımenlı et al., 2016). The achievement and quality of athletes in various sports must be improved through an appropriate training model so as not to decline.

The trainer must be able to create a training programme that is able to support the potential of the athlete and can provide maximum performance. Training for most sports requires different physical qualities to be emphasised across an annual period, with the overall goal to improve sports performance during competition (Mazurek et al., 2018). Sports activities have the benefit of being able to help increase stamina, being able to lose weight and strengthen muscles.

Everyday life in the world is inseparable from various forms of physical activity that require a lot of energy or a little energy. In exercising, there will be changes in the body according to the type, length and severity of the exercise being carried out.

So, physical activity that is carried out regularly in sufficient quantities and for a long time will have an impact on one's health and fitness. Sports activities in the country, especially in Indonesia, still require special guidance and training, both in finding new athletes and

in efforts to increase prestige.
Through systematic sports coaching, the quality of human resources can be directed at increasing self-control, responsibility, discipline, and productivity, which in turn can gain achievements that can arouse national pride. Achievement is no longer the property of individuals, but it is related to the dignity of a nation. That is why various efforts and endeavours have been made by a region or a country to place its athletes as champions in various major sports activities.
To get athletes who excel, good training and competitions are needed. The development of the physical condition must receive serious attention, and the coach must use a good and correct method. Physical condition has a very dominant role in improving the performance or achievement of athletes, especially in competitive sports. To achieve a successful performance in all sports, athletes should have sufficient motoric and physical strength pertinent with their branches (Çımenlı et al., 2016).

Plyometric exercises combine strength and speed to produce more power that engages muscles to produce muscle spindles. Most of the studies on the effects of plyometric training have demonstrated improvements in vertical jump performance (Mazurek et al., 2018). Looking at the physical activities carried out during hurdle hops training, it is clear that this physical activity is an "intermittent" activity, meaning a form of activity consisting of work intervals interspersed with rest intervals (relief intervals). Plyometric training (PT) is a form of explosive strength training that uses explosive movements to develop muscular power, which is the ability to generate a large amount of force quickly (Lum et al., 2019). However, despite the increase in muscular power, the current results showed that there was no increase in post-test jump height (Lum et al., 2019).

This is an important gap in the research that should be considered and corrected in further studies conducted in youth players (Silva et al., 2019). Good physical condition will positively contribute to athletes in mastery of techniques in sports. Excellent physical condition will have a big influence on the achievement of an athlete. An athlete must have a physical condition component in an effort to optimise his ability to attain an achievement.

Plyometric exercise is included in anaerobic muscle metabolism whose advantage is that it can renew ATP without depleting oxygen, but the effect is the emergence of lactic acid in the blood. If a lot of lactic acid accumulates in the muscles, its function will weaken and cause fatigue. Plyometric exercises involve a rapid eccentric movement, followed by a short amortisation phase, which is then followed by an explosive concentric movement, enabling the synergistic muscles to engage in the myotatic-stretch reflex during the stretch-shortening cycle (SSC) (Lum et al., 2019). Another important factor that may determine the effectiveness or the amplitude of the benefits of plyometric interventions is the duration of the training period (Silva et al., 2019).

In sports, the effort to achieve success is not easy and short. Training is a systematic process to improve the work quality of athletes where the body and mind are constantly exposed to pressures of various quantities or volumes and intensities based on a theory so that a good result is achieved.

The aim of training in general is to conceptually improve skills and abilities in helping to reveal the sport potential possessed by athletes in accordance with the specialisation of the sport. In addition, the athlete's age and sex should be considered when planning strength training programmes (Silva et al., 2019). To improve the physical condition, there are several methods that can be applied, and training methods that lead to increased endurance capacity and short interval training are more effective in increasing anaerobic capacity. The advantage of this interval training is to know the load precisely and be able to see progress quickly, meaning that it can increase energy and physical condition that can be done more efficiently. Interval training is the only training method that has variations and can be adjusted to develop the main energy system.

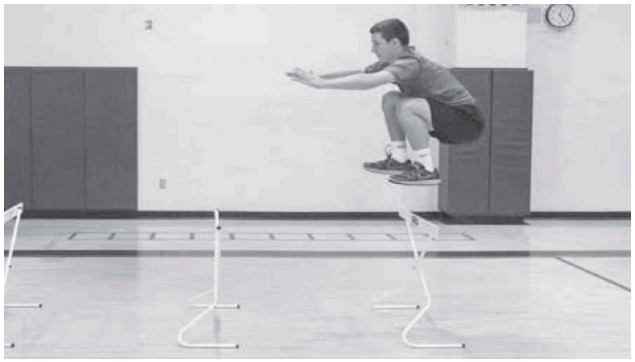
The contribution of the main energy system to hurdle hops training depends on the interval activity. Using work intervals, the main energy system used is the anaerobic system, while the main energy system used during rest intervals is the aerobic system. Strength is the ability to produce or generate increased strength and generate a force to withstand loads.

The plyometric training method is currently the method most often used by trainers in providing training in various sports. Plyometrics is used to increase speed or muscle strength, along with the goal of increasing jumping height or speed of punches or throws. Plyometric exercises on a 2 leg jump are better at giving a greater impact and are able to increase the leg muscle strength and the vertical jump with short-term training.

The principle of plyometric training is that the muscles always contract both when they are elongated (eccentric) and short (concentric). The stretching forces that occur during movement give rise to eccentric muscle contractions with the resulting stored elastic energy, which contributes to an increase in strength in subsequent concentric contractions (Fischetti et al., 2018). Plyometrics constitute a very fast and powerful movement, that is, a very explosive movement. Thus, it needs ATP-PC energy that can fulfil, even though it cannot be separated from other energy systems.

Energy is stored in the phase of slowing down, and energy is released in the acceleration phase (Çımenlı et al., 2016). Most of the exercises are specifically for the leg and hip movements because this muscle group is the centre of power in the sports movement. Plyometric movements use mostly eccentric and concentric contractions. The main finding was that plyometric training is more likely to provide greater benefits to vertical jump than sprint speed (Fischetti et al., 2018).

Hurdle hops training is a form of plyometric training that is useful for increasing leg muscle strength. As for the muscles that it affects, they are: gastronemicius, biceps femoris, gluteus, brevis, soleus, extensor digitorium, vastus lateralis, quadriceps, hamstrings, calves and tibialis anterior.



Picture 1: Hurdle Hop Forms

Several studies have been conducted on exercise using low-intensity, moderate-intensity and high-intensity interval training. The use of intervals is adjusted to the situation and conditions of the person who will do it. This interval training system includes alternating periods of work and rest. The advantage of this training is that more athletes experience intensity training without experiencing excessive fatigue. Interval training is the primary medium for realising specific training effects. Interval training not only allows the athlete to work at a volume greater than a certain intensity, but also allows the athlete to train harder than he does in continuous training.

Interval training is an exercise programme consisting of periods, repetitions of work that are interspersed with rest periods or is a series of exercises that are repeated and interspersed with rest periods. 1:6 interval training increases the component of leg muscle strength, where the recovery time is shorter, so it is appropriate for hurdle hops training that has low leg muscle power because it is more concentrated in doing the exercise; therefore, with a shorter time, having low leg muscle power can increase the strength of leg muscles and display the acceleration of movement according to their abilities.

METHOD

The type of research used in this research is quantitative with experimental methods. The approach used in this research is quasi-experimental with a matching-only design. The population of participants in the volleyball performance guidance for the Faculty of Sports and Health, Undiksha Singaraja, totalling 11 students, lasted for 2 months. The research began with a pre-test, treatment and post-test. Research instruments include the JUMP-DF. The test results are recorded and calculated based on the group and type of exercise applied. Data descriptions use the SPSS (Statistical Package for the Social Sciences) computer program 17.

RESULTS

The type of research used in this research is quantitative with experimental methods. The approach used in this research is quasi-experimental with a matching-only design. The population of participants in the volleyball performance guidance for the Faculty of Sports and Health, Undiksha Singaraja, totalling 11 students, lasted for 2 months. The research began with a pre-test, treatment and post-test. Research instruments include the JUMP-DF. The test results are recorded and calculated based on the group and type of exercise applied. Data descriptions use the SPSS (Statistical Package for the Social Sciences) computer program 17.

Table 1: Descriptive Statistics

	N	*Mean*	Std. Deviation	*Maximum*	*Minimum*
pre-test strength	11	116.55	34.99	173.00	60.00
post-test strength	11	144.45	27.05	182.00	95.00

Table 2: The Results of Limb Muscle Strength Data Normality with Techniques One-Sample Kolmogorof-Smirnov Test

	Interval training method	
	Hurdle hops 1:6	
	pre-test	*post-test*
Sig.	0.998	0.982
Ket	p > 0.05	p > 0.05
Status	Normal	Normal

The homogeneity test in this study was carried out on the mean different data from each group using the Levene's test on the SPSS computer program.

Table 3: Data Homogeneity Test - Mean Different Leg Muscle Strength

Levene's Test of Equality of Error Variances[a]

	Levene statistic	df1	df2	Sig.
Based on mean	.593	2	31	.559
Based on median	.478	2	31	.625

If it is seen from the results of the data in the table above, it shows that the significant value of all data is more than 0.05, it can be concluded that the data is homogeneous. After knowing that the resulting data is normally distributed and homogeneous, the research data is suitable for use in conducting further analysis. In conducting a different hypothesis test, the dependent variable in paired samples uses a t-test analysis, which is called the paired t-test in SPSS.

Table 4: Paired Sample Test - Leg Muscle Explosive Power Test

Paired Samples Test

		Mean	t	Sig. (2-tailed)
K1	posttest leg muscle strength- posttest leg muscle strength-	-2.08324	-4.516	0.001

DISCUSSION

In the study, plyometric training programmes of 8-week duration resulted in significant increases in vertical jump height (Hermassi et al., 2014). Plyometric exercises are useful for increasing muscle nerve reactions, explosiveness, speed, and the ability to generate force (power) in a certain direction. From a practical perspective, the present findings suggest that traditional plyometric training is sufficient to enhance power output in beginners (Makaruk et al., 2010). Hurdle hops training is a form of plyometric training that is useful for increasing leg muscle strength. Based on the calculation of the mean, the results of the hurdle hops group training at 1:6 intervals experienced an increase in the average leg muscle strength results. The pre-test and post-test of leg muscle strength are from 116.55 kg to 144.45 kg, whereas the different test with a paired t-test shows that the significance level of each variable is obtained Sig. < 0.05; thus, there is a significant effect or there is a difference between the pre-test and post-test data of each dependent variable, both explosive power and leg muscle strength.The findings suggest that plyometric training positively affects horizontal jump performance, albeit with improvements lower than those recorded for vertical jump performance (9% to 28%, as observed previously (Silva et al., 2019). During work in the exercise period at maximum intensity, there is a depletion of ATP and creatine phosphate (CP) reserves in the muscles. Plyometric exercise provides the usage of elastic properties of muscle fibres and connective tissues (Çımenlı et al., 2016). ATP and PC reserves spent during the work interval will be replenished via the aerobic system in the recovery period. Anaerobic interval training 1:6 increases the component of leg muscle strength, where the recovery time is shorter, so it is appropriate for hurdle hops training that has low leg muscle power because it is more concentrated in doing the exercise; therefore, with a shorter time, having low leg muscle power can increase leg muscle strength and display the acceleration of movement in accordance with his ability. Thus, despite the findings reported in previous studies, plyometric training may be an effective way to increase athletes' flexibility, which could facilitate improvements in jump performance, agility and speed (Silva et al., 2019).

CONCLUSION

Based on the results of the research and discussion, it can be concluded that hurdle hop training with 1:6 intervals is effective for the leg muscle strength of volleyball players. Sports coaches and other sports players can use hurdle hop training recommendations, using 1:6 intervals as well as a component of leg muscle strength.

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EFEKAT TRENINGA SA PRESKAKANJEM PREPREKA I INTERVALOM 1:6 NA SNAGU MIŠIĆA: ODBOJKAŠI

Sport je trenutno jedna od najvažnijih potreba zajednice, pa se može vidjeti tamo gdje se ljudi bave sportskim aktivnostima. Ljudi već znaju da je vježba korisna za zdravlje i kondiciju. Odbojka je jedan od najpopularnijih sportova u Indoneziji. Ova studija ima za cilj utvrditi efekat treninga sa preskakanjem prepreka u intervalima 1:6 na snagu mišića nogu. Ova studija je bila kvazieksperimentalna, a populaciju u ovoj studiji su činile sve obuke postignuća u odbojci koje je 11 sportista moglo izvesti. Korišten je instrument JUMP-DF. Analiza podataka je provedena korištenjem t-testa. Rezultati testa pokazuju da postoji značajna razlika ili efekat treninga sa preskakanjem prepreka korištenjem intervalnog treninga 1:6 na snagu mišića nogu odbojkaša, a što je značajno na 0,001 < 0,005. Prema tome, trening sa preskakanjem prepreka korištenjem intervala 1:6 je prikladan za poboljšanje spremnosti odbojkaša.

Ključne riječi: preskakanje prepreka, intervalni trening, snaga mišića nogu

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COMPARISON OF THE KNEE ABDUCTION MOMENT AND ANGULAR IMPULSE BETWEEN MALE AND FEMALE RUNNERS

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2. College of Sports Science and Technology, Thailand

ABSTRACT

Running is a popular form of exercise for all populations. It has been reported that runners have experienced running injuries such as patellofemoral pain and ACL injuries. In addition, the influence of gender on running mechanics has been reported. Knee abduction moment is a method to measure stress on the surface of the knee joint. The objectives of the study were to investigate the knee abduction moment and angular impulse and to compare the differences of the knee abduction moment and angular impulse in male and female recreational runners during running. Ten male subjects and ten female subjects, who regularly exercised by running and doing sports activities, were recruited to the study. A motion analysis system with eight infrared cameras was positioned around the field in which the participants ran across. The participants were required to run at a controlled speed of 3.5 meters per second within 5% accuracy and landed on their dominant foot in the middle of a force plate. Each subject performed three successful trials while barefoot and wearing athletic shoes. The peak knee abduction moment and angular impulse were calculated during ground contact. The results revealed that there were significant differences found for males for peak knee abduction moment and knee angular impulse. The effect of gender showed that no significant differences were found for peak knee abduction moment and knee angular impulse. In conclusion, there were significant differences for the knee abduction moment and angular impulse in males, but no significant differences were found between genders. Male runners may possibly be aware of the opportunity to develop running injuries as female runners.

Keywords: knee abduction moment, angular impulse, running injuries

INTRODUCTION

Physical inactivity has been cited as the 4th leading global risk factor for death, especially in middle to high income countries (WHO, 2009). It is associated with increased chronic diseases, decreased longevity and loss of physical functions.

Running is one of the most popular form of exercise and convenient leisure-time physical activity for all populations because of its easy accessibility and it is a feasible way for people to become more active. However, there has been evidence reported that runners have experienced running injuries' problems in the range of 19% - 83%, as the popularity of marathon running grows (Buist et al., 2010).

The most common problems with running injuries are patellofemoral pain, iliotibial band syndrome, ACL injuries, medial tibial stress syndrome, tibial or metatarsal stress fractures, plantar fasciitis, and Achilles tendinopathy (Lopes et al., 2012).

In addition, vertical loading rates (Zadpoor & Nikooyan, 2011), the knee abduction moment (Stefanyshyn et al., 2006), strike length (Edwards et al., 2009) and rearfoot strike pattern (Lieberman et al., 2010) are considered to be the factors that cause injury from running as well.

Patellofemoral pain (PFP) is known as the most common disorder of the knee encountered during running (Fagan & Delahunt, 2008), which is a result of the contact between the distal end of the femur and the posterior surface of the patella during dynamic activities (Besier et al., 2005). In addition, it has been reported that PFP is an initiation and progression of knee osteoarthritis (Crossley, 2014).

The measurement of stress that occurs at the surface of the joints is difficult to do in humans. Therefore, a method for measuring the external knee abduction moment is used to measure the peak moment of input in the knee (Vincent et al., 2012), which indicates the dynamic knee joint load which can be calculated from the ground reaction force (GRF) multiplied by the perpendicular distance between the centre of the joint and the lever arm.

Increased knee abduction is commonly considered to be an inappropriate movement pattern, incorporating greater knee abduction (Herrington, 2014).

Greater knee abduction has been reported to increase forces within the patellofemoral joint, and previous studies indicate an increased risk of knee injury in individuals during weight-bearing activities (Krosshaug et al., 2016).

Several studies have examined the influence of sex on running mechanics in younger adults (Chumanov et al., 2008; Ferber et al., 2003). It is suggested that increased knee abduction may be a contributing factor for this gender difference (Weiss & Whatman, 2015; Chumanov et al., 2008).

Females have a greater magnitude of knee abduction during activity than men, and this is widely spread in the research and clinical sport setting (Sigward et al., 2012).

During running, females reportedly have higher knee valgus angles, higher peak hip adduction moments, and higher knee abduction than males (Ferber et al., 2003).

The objectives of the study were to investigate the knee abduction moment and angular impulse and to compare the differences of the knee abduction moment and angular impulse in male and female recreational runners during running.

METHODS

Subjects

Ten male subjects (mean ± SD: age 23.4 ± 2.95 years; height 170.7 ± 5.91 cm; weight 70.16 ± 8.36 kg; BMI 24.1 + 2.89 kg/cm2) and ten female subjects (age 26.7 ± 7.36 years; height 162.6 ± 6.29 cm; weight 56.58 ± 7.34 kg; BMI 21.4 + 2.58 kg/cm2), who regularly exercised by running and doing sports activities, were recruited to the study. Participants were excluded from this study if they reported any history of a musculoskeletal injury within the prior 6 months, a fracture or surgery of the lower extremities or trunk, or knee injuries. Ethical approval was obtained from the Burapha University Institutional Review Board (BUU-IRB) No. Sci 099/2561 prior to participating in recruitment. A written informed consent was obtained from each participant before the study was performed.

Measurements

Before biomechanical testing, anthropometrics were measured and recorded for each subject, including body weight, height, leg length, and range of motion (ROM) of trunk and lower extremities. Each subject was instrumented with 24 retroreflective markers placed bilaterally on the ASIS, sacrum, greater trochanter, thigh, medial and lateral knee, shank, medial and lateral malleoli, heel, lateral foot, toe and right side of scapula (to locate the side). A static trial was collected in which the participant was instructed to stand still in the anatomical position with foot placement standardised to the laboratory coordinate system. This static measurement was used as each participant's neutral (zero) alignment. A motion analysis system (SMART-DX, BTS Bioengineering, USA) with eight infrared cameras was positioned around the field in which the participants ran across. The calibration procedure was done in two steps. First, a static calibration was performed to determine the global coordinate system by a rigid L-frame and then a dynamic calibration was performed to calibrate the working volume by using a dynamic wand to register the cameras to the whole capture volume. Two force platforms (AMTI, Watertown, MA), sampled at 800 Hz and synchronised with the motion analysis system, were embedded into the floor so that the foot would contact a platform during the stance phase of running.

The participants were required to run at a controlled speed of 3.5 meters per second within 5% accuracy monitored by the Speedlight timing system (Swift Performance Equipment, US) placed apart on either side of the force platforms, and landed on their dominant foot in the middle of a force plate. The force plate was centred between the timing gates which were set up to control the speed of running. Each subject performed three successful trials while

barefoot and wearing athletic shoes, with 5-minute rest intervals. Three-dimensional marker trajectories were examined and exported to a C3D formatted file for further analysis in Visual3d (Version 4.0, C-Motion, Inc., MD). Kinematic data were combined with force data to calculate the knee abduction moments and normalised to each subject's body weight (Nm/(kg*m)). The peak knee abduction moment and angular impulse were calculated during ground contact.

Statistical analysis

The descriptive statistics of means and standard deviations were used to describe the outcome measures and the characteristics of participants. The paired t-test was used for analysing the differences between genders. The normality of the distribution of the values for the peak knee abduction moment and angular impulse was investigated using Shapiro-Wilk tests. A Wilcoxon signed-ranks test was conducted for the average values of the peak knee abduction moment and angular impulse which showed an abnormal distribution, and the paired t-test was used to examine the average values of normalised ground reaction force and stance time between shoe conditions. A Mann-Whitney test was conducted for the average values of the peak knee abduction moment and angular impulse which showed an abnormal distribution, and an independent t-test was conducted for average values of normalised ground reaction force and stance time between genders. All statistical analyses were conducted using the statistical software programs with statistical significance accepted at the $p < 0.05$ level.

RESULTS AND DISCUSSION

Demographic characteristics for all participants are summarised in Table 1. All participants were in the same age range, but there were differences in body height, weight and BMI. Male participants were taller, heavier and with a higher BMI than those of females ($p < .05$).

Table 1: Demographic characteristics for participants

	Male (n = 10)	Female (n = 10)	t	p-value
Age (years)	23.4 (2.95)	26.7 (7.36)	-1.315	0.21
Height (m)	1.71 (0.06)	1.63 (0.06)	3.861	0.001*
Weight (kg)	70.16 (8.36)	56.58 (7.34)	2.968	0.008*
BMI (kg/m^2)	24.1 (2.89)	21.4 (2.58)	2.201	0.041*

* Significant difference between groups ($p < 0.05$).

Comparison between footwear types

When comparing between being barefoot and wearing shoes, there were significant differences found for males for peak knee abduction moment ($z = -1.988$, $p = 0.047$) and knee angular impulse ($z = -1.988$, $p = 0.047$), as shown in Figure 1a and b, but there were no significant differences found for ground reaction force ($t9 = -2.21$, $p = 0.054$) and stance time ($t9 = -2.077$, $p = 0.068$). There were no significant differences found for females for peak knee abduction moment ($z = -0.459$, $p = 0.646$), knee angular impulse ($z = -0.459$, $p = 0.646$), ground reaction force ($t19 = -0.508$, $p = 0.624$), and stance time ($t9 = -0.418$, $p = 0.686$).

Table 2: Peak knee abduction moment, knee angular impulse and ground reaction force during running when comparing between footwear types and between genders

	Barefoot		Sports shoes	
	Male	Female	Male	Female
Peak knee abduction moment (%Bw*Ht)	1.9 (0.58)	1.07 (0.36)	2.22 (0.56) *	1.14 (0.42)
Knee angular impulse (%Bw*Ht*s)	0.44 (0.15)	0.23 (0.08)	0.51 (0.15) *	0.24 (0.09)
Ground reaction force (Nm/BW)	1.11 (0.02)	1.13 (0.03)	1.1 (0.02)	1.14 (0.02)
Stance time (s)	0.22 (0.01)	0.21 (0.01)	0.25 (0.01)	0.23 (0.01)

* Significant difference between groups ($p < 0.05$).

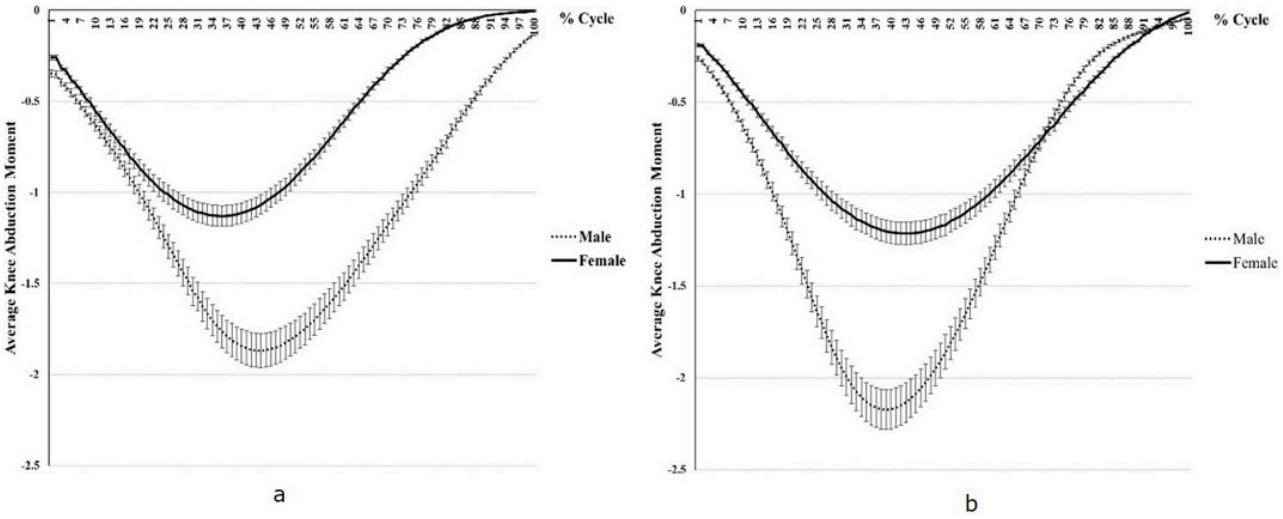

Figure 1: Average knee abduction moment between male and female; (a) barefoot and (b) footwear

Comparison between genders

The effect of gender showed that no significant differences were found for peak knee abduction moment; barefoot (z = -0.302, p = 0.762), wearing shoes (z = -0.983, p = 0.326), knee angular impulse; barefoot (z = -0.605, p = 0.545), wearing shoes (z = -1.508, p = 0.29), ground reaction force; barefoot (t18 = -0.652, p = 0.523), wearing shoes (t18 = -1.383, p = 0.184), and stance time; barefoot (t18 = 0.892, p = 0.384), wearing shoes (t18 = 1.899, p = 0.074).

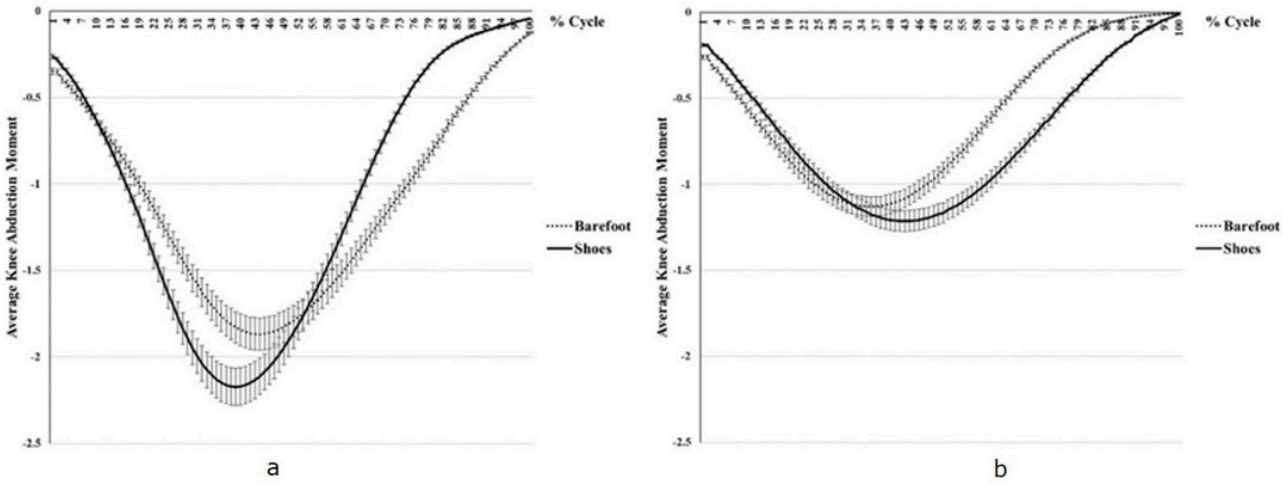

Figure 2: Average knee abduction moment between barefoot and footwear; (a) male and (b) female

The purposes of the study were to investigate the differences of knee abduction moment and angular impulse during running and the differences of knee abduction moment and angular impulse, and to compare the differences of the knee abduction moment and angular impulse in male and female recreational runners. No differences in knee abduction moment and angular impulse ground reaction force and stance time were observed between male and female recreational runners in the present investigation. The results of the present investigation are in contrast to the previous study which demonstrated that the maturation resulted in greater knee abduction moment in female but not in male athletes (Hewett et al., 2015). Due to the lower extremities' structure, a female has a wider Q-angle than that of male or has lower muscle strength than a male. Some research reported that females have higher rates of lower extremities' injuries immediately

following the growth spurt due to the absence of corresponding neuromuscular adaptation, and might not develop the neural adaptation to match the demands of growth during the adolescent to the maturation period (Brent et al., 2013). However, the neuromuscular spurt, the natural adaptation of increased power, posterior chain postural strength, and coordination that occur with increasing chronological age and maturational stage in adolescence may naturally reduce the differences in neuromuscular control of the lower extremity between males and females (Myer et al., 2009).
The male runners in the current study exhibited significantly higher peak knee abduction moment and angular impulse while running barefoot, compared to wearing sports shoes. It is interesting that both males and females had increases in the knee abduction moment. Neuromuscular patterns of thigh muscle play a role to provide the joint's stability and position. Skeletal growth and body mass gain during adolescence of males might affect the centre of mass and make it difficult to control the body position during dynamic movements, especially the knee joint (Hewett et al., 2004). Knee joint stability arises from the integration of joint geometry, passive tissue restraints and compressive forces from muscular contractions. The muscles surrounding the joint help keep the stiffness and stability of the joint for optimal dynamic movements. They work in conjunction to stabilise the joint when ground reaction force is applied during running. The major muscles crossing the knee are typically categorised as knee flexors and extensors. Although the knee joint range of motion is greatest along the sagittal plane, physiological loading conditions are multifactorial and do not limit loads to a single axis of rotation. Quadriceps play a role as general knee stabilisers (Flaxman et al., 2013) and provide rotational stiffness in all loading planes (Cashaback & Potvin, 2012). As the knee joint's muscles primarily function in the sagittal plane, quadriceps-hamstrings activation should have sufficient control of the resultant ground reaction force within the sagittal plane. Muscle imbalance has the potential to decrease performance or induce joint instability, which may result in traumatic knee joint injuries (Hewett et al., 2005). Previous studies indicated knee instability in the frontal plane caused by muscle weakness appeared to be an injury mechanism (Sritharan et al., 2016). As the work of Hashemi et al. (2007) found significant reduction of ACL strain when the quadriceps muscle strongly contracted during landing, other studies found that significant reductions of the medial side of the quadriceps muscle activation increase the risk of valgus loading (Hubley-Kozey et al., 2009). If these muscles become imbalanced, this may lead to altered biomechanical movement patterns and facilitate the development of significant risk factors on the knee joint such as patellofemoral pain syndrome (PFPs), osteoarthritis and ACL injury.

CONCLUSIONS

In conclusion, the study investigated the differences of the knee abduction moment and angular impulse in male and female recreational runners during running. The results revealed that there were significant differences found for males for peak knee abduction moment and knee angular impulse. The effect of gender showed that no significant differences were found for peak knee abduction moment and knee angular impulse. Running at a recreational level was associated with running injuries, such as PEPs and ACL injuries, and was able to develop knee osteoarthritis. Based on the results of this study, male runners may possibly be aware of the opportunity to develop running injuries as female runners.

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POREĐENJE MOMENTA ABDUKCIJE KOLJENA I UGAONOG IMPULSA IZMEĐU TRKAČA I TRKAČICA

Trčanje je popularan oblik vježbe za sve populacije. Zabilježeno je da su trkači zadobili povrede tokom trčanja poput patelofemoralne boli i povrede prednjeg križnog ligamenta. Nadalje, zabilježen je i uticaj spola na mehaniku trčanja. Moment abdukcije koljena je metoda mjerenja naprezanja na površini zgloba koljena. Ciljevi ove studije su bili istražiti moment abdukcije koljena i ugaoni impuls te uporediti razlike momenta abdukcije koljena i ugaonog impulsa kod rekreativnih trkača i trkačica tokom trčanja. U studiju je uključeno deset muških i deset ženskih ispitanika, a koji su redovno vježbali tako što su trčali i bavili se sportskim aktivnostima. Sistem analize pokreta sa osam infracrvenih kamera je postavljen oko staze na kojoj su učesnici trčali. Učesnici su morali trčati kontrolisanom brzinom od 3,5 metra u sekundi uz preciznost od 5% te se zaustaviti dominantnom nogom na sredini platforme za mjerenje sile reakcije podloge. Svaki ispitanik je izveo tri uspješna pokušaja bosih nogu i u atletskoj obući. Maksimalni moment abdukcije koljena i ugaoni impuls su izračunati tokom kontakta sa tlom. Rezultati su otkrili postojanje značajnih razlika kod trkača za maksimalni moment abdukcije koljena i ugaoni impuls koljena. Efekat spola je pokazao nepostojanje značajnih razlika za maksimalni moment abdukcije koljena i ugaoni impuls koljena. Zaključno, značajne razlike su postojale za moment abdukcije koljena i ugaoni impuls kod muškaraca, ali nisu pronađene značajne razlike između spolova. Trkači su vjerovatno svjesni mogućnosti povreda tokom trčanja kao i trkačice.

Ključne riječi: moment abdukcije koljena, ugaoni impuls, povrede tokom trčanja

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DECORATIVE STICKERS FOR TEETH: THERMAL INSULATION OF TEETH IN ATHLETES DURING COMPETITIONS AND TRAINING IN THE COLD

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ABSTRACT

During sports competitions and outdoor training in frosty weather, athletes often perform the maximum possible physical activity that requires a lot of oxygen. The increased need for oxygen forces athletes to quickly inhale cold air with all their lungs using an open mouth. Inhaling cold air through the open mouth leads to local cooling of the teeth. The degree and duration of local cooling of the teeth increases as the frost, wind and snowfall increase, and the duration of inhaling cold air with an open mouth also increases. At the same time, local cooling of the teeth can cause their cold damage, which is accompanied by toothache. The features of the pathogenesis of cold tooth injuries and temperature toothache during local cooling in frosty weather, based on modern data found in the literature, are described. To maintain high sports results, preserve a good mood, the health of athletes, and especially the integrity and safety of their teeth in the winter season, it is recommended to insulate the teeth with a special decorative sticker. It is shown what features should be taken into account for the thermal insulation of teeth in athletes in normal conditions, as well as in the presence of braces. The article describes the essence of modern decorative stickers intended for thermal insulation of teeth when inhaling cold air in frosty weather. The purpose of this work is to give practical recommendations for the preparation of training sessions and sports competitions in the open air in the winter season.

Keywords: sports training, frosty air, teeth, caries, injury prevention

INTRODUCTION

Athletes engaged in winter sports, such as cross-country skiing, biathlon, slalom, bobsleigh, orienteering, and others similar to them, most often participate in training and in sports competitions held in the open air in cold conditions. Moreover, this category of athletes is forced to spend a significant part of the time throughout the year in cold conditions, since high-quality training and sports competitions themselves are possible only in cold weather conditions [1-4]. Therefore, it is no accident that athletes from

all over the world come to countries located in the northern latitudes or having high mountains with snow on them for training and sports competitions. In this regard, this category of professional athletes is located outside of warm rooms and breathes cold air not only during sports competitions and training, but also between them [5-7]. However, it has long been noted that inhaling cold air and/or drinking cold water can cause toothache, and repeated prolonged temperature changes in the oral cavity will contribute to the destruction of tooth enamel [8, 9].

It is shown that low ambient temperature, on the one hand, can improve the results of sports competitions [10], and on the other hand, can cause cold damage to various parts of the body [11]. It is established that, in athletes, cold injuries are most often received by open parts of the body, such as the head and hands. In particular, in the head area, frostbite often occurs in the nose, ears and cheeks [12, 13]. It is shown that in the area of the extremities, cold injuries often occur in the fingers of the hands [14].

Moreover, the local cooling of the limbs begins with the fingertips [15]. It was also shown that when inhaling air, local cooling of hard and soft tissues begins from the area of the vestibule of the oral cavity [16, 17]. It was also found that local cooling of the peripheral parts of the body (the tips of the nose, fingers and toes) can occur not only in the cold, but also at room temperature, if hypoxia appears in the body. It is established that the cooling of peripheral tissues in hypoxia occurs due to a compensatory reaction of the body, which manifests itself in the peripheral areas of the body in the form of a decrease in microcirculation in them [18, 19]. In particular, local cooling in the fingertips was found in healthy volunteers with voluntary breath retention and in pregnant women with thrombophilia [19-21]. However, the effect of hypoxia on the local temperature of teeth in people in the cold remains unknown.

It is no secret that hypoxia always occurs in the body of athletes with very intense and prolonged physical activity, which they perform at the limit of their capabilities [22]. In this regard, during sports competitions and training in the cold, the dynamics of the local temperature in the open areas of the athletes' body can change not only from their direct cooling with cold air, but also from a decrease in peripheral microcirculation.

Really, the spasm of blood vessels that occurs with the deterioration of peripheral microcirculation in the tissues of open and cooled parts of the body, including the teeth, can cause "cold" pain in them and reduce the delivery of warm arterial blood to them. However, current guidelines on sports medicine do not include cold tooth damage and cold toothache in the list of cold injuries of athletes engaged in winter sports [11, 23-25]. In addition, there are no studies aimed at studying the relationship between the condition of the teeth and their multiple repeated local cooling in athletes engaged in winter sports. At the same time, dentists have found that, in people living in cold conditions, teeth are more often damaged by caries.
Bilateral damage to the premolars is particularly common [26]. More frequent damage to the side teeth in people who often inhale cold air with an open mouth may be due to the fact that cold air is most intensely introduced into the oral cavity from the sides, and not in the middle. But the safety of teeth with repeated and prolonged inhalation of cold air through an open mouth in athletes is not sufficiently studied, and methods of protecting teeth from cold toothache and from cold damage are not developed.

In recent years, the importance of this problem has also increased because among athletes engaged in winter sports, the number of those who have had titanium implants, metal-ceramic or ceramic crowns installed in the oral cavity is increasing.
It is quite obvious that braces and other dental constructions were not developed for athletes engaged in winter sports. So, these constructions do not protect the hard and soft tissues of the oral cavity from cold destruction when inhaling cold air with an open mouth. In addition, metal and ceramic materials that are used for the manufacture of braces and other dental constructions are not intended for thermal insulation of teeth in the cold [27]. Moreover, these materials do not have thermal insulation properties [28].

At the same time, the role of braces and other dental constructions in cooling the teeth when inhaling cold air during sports competitions and training is not fully understood [29-31]. Also, the influence of these dental constructions on cold tooth damage and cold pain in the mouth in military personnel and polar explorers during intensive mouth inhalation of frosty air in northern latitudes, as well as in the Arctic and Antarctic has not been studied [32, 33]. And finally, it should be added that winter sports equipment does not include special "winter" thermal insulation stickers to protect teeth from cold damage [34].

In this regard, the development of special heat-insulating dental stickers for athletes engaged in winter sports is very relevant and timely, as it will allow athletes and competition coordinators to more reliably avoid damage to teeth by cold. This requires innovative developments using efficient and safe materials. This information is necessary not only for athletes, sports coaches, competition organisers and sports doctors, but also for manufacturers of winter sports clothing and sports equipment, since only in this case will it be possible to implement the best strategy for preventing cold injuries of teeth in the cold in a short time.

THE ORAL CAVITY TISSUES TEMPERATURE IN NORMAL STATE AND IN THE PRESENCE OF BRACES

It has long been known that athletes engaged in winter sports have a high probability of developing frostbite and other cold injuries in frosty weather [14]. It is believed that cold damage is caused by cold air; so, to prevent frostbite and other cold damage during training and sports competitions in the cold, it is necessary to use special winter clothing and winter equipment [19, 20, 35]. However, the effect of general and local hypothermia on the human body during acclimatisation is still not completely clear. In particular, it is shown that an increase in the duration of people's stay in the cold reduces the probability and degree of cold damage, since there is an increase in resistance due to the partial general acclimatisation of people to the cold [36]. To assess the resistance of people (in particular, polar explorers, military personnel or athletes) to the upcoming stay in the fresh air in frosty weather (in particular, in the winter season in northern latitudes), a special method for assessing individual resistance to re-cooling has been developed and invented (RU Patent 2578091). The essence of the invented technique is to measure, using a thermal imager, the dynamics of the local temperature in the human hand after it is lowered into the water with melting snow for 2 minutes. In the case when, after local cooling, the temperature in the fingertips is equal to or exceeds the temperature of the centre of the palm, it is concluded that the person has a high resistance to frostbite. But this method is not applicable for assessing the resistance of teeth to cooling.

On the other hand, preliminary local cooling of the teeth has long been used in dentistry for diagnostic purposes to identify the tooth affected by caries [37]. The essence of this technique is that, in the case of a tooth lesion with caries, with local cooling, toothache immediately occurs in it. Usually, in the presence of caries, a person himself feels the appearance of toothache when drinking cold water and/or inhaling cold air. In this regard, athletes with teeth affected by caries are unlikely to be able to actively inhale cold air with an open mouth, since this will cause local cooling of all teeth, including the diseased tooth, which will cause toothache. However, athletes with healthy teeth and athletes who have received timely dental care do not suffer from severe toothache when inhaling cold air. Therefore, normally, athletes usually safely inhale the frosty air during sports competitions and outdoor training, despite the frosty weather. People with braces, with dental crowns and with implants installed can also go out in the cold because modern dental recommendations do not contain restrictions that would be associated with cold damage to the hard and soft tissues of the oral cavity when people go out into the open air [38]. In addition, for toothache, any person, including any athlete, usually takes an analgesic medication himself. Then, after the medicine reduces the toothache, people start their normal activities both indoors and outdoors, regardless of the weather conditions and the ambient temperature.

For this purpose, all over the world, it is recommended to take non-steroidal anti-inflammatory drugs from the aspirin group by ingesting them (in the stomach). Therefore, an athlete can also take an analgesic medication before going out in the cold to participate in sports competitions or in training. However, nonsteroidal anti-inflammatory drugs do not insulate the teeth, do not protect them from local cooling, and they do not save the tooth enamel from cold destruction, but they are dangerous due to the ulcerogenic effect on the stomach wall [39]. That is why the use of nonsteroidal anti-inflammatory drugs cannot protect not only the teeth, but also the nose, cheeks, and fingers from cold pain and from cold damage.

The dynamics of the local temperature pertaining to the front surface of the teeth in adult healthy volunteers was studied when inhaling cold air with an open mouth for 10 minutes at an air temperature of -10 °C [40]. The results of the research showed that the local temperature in the hard and soft tissues of the oral cavity in all the studied people in the conditions of room temperature before going out into the cold was normal and practically did not differ from each other.

Then, after starting to inhale cold air with an open mouth, the local temperature of the hard and soft tissues began to decrease very quickly. Hard tissues were the fastest to cool. Out of these, the most quickly and significantly cooled were the installed metal dental crowns and braces. Then, after starting to inhale cold air with an open mouth, the local temperature of the hard and soft tissues began to decrease very quickly. Hard tissues were the fastest to cool. In some volunteers, this caused a cold toothache. After 10 minutes of being in the cold and inhaling cold air with an open mouth, the local temperature in the hard and soft tissues of the oral cavity was reduced in all of the researched volunteers. However, in some people, braces can cause local hyperthermia in the soft tissues of the oral cavity [41].

It was found that braces can cause local irritation of the inner surface of the lips and cheeks due to friction, which increases during chewing food, pronunciation of words, and during other activation of the mechanical activity of the lips and cheeks. It has been shown that braces have a strong local irritant effect and cause local hyperthermia only in soft tissues and only for 2 weeks after the installation of the braces.

At a later time, the adaptation of soft tissues occurs and they stop becoming inflamed. At the same time, the temperature of the teeth remains normal from the first day of the installation of braces [42].

To detect their local hypo -, hyperthermia, irritant, inflammatory, and damaging effects, it is recommended to use a thermal imager [43]. However, the diagnostic value of thermal imaging monitoring and the pathological value of these dental constructions for cold injuries of the oral cavity when inhaling frosty air remains unexplored.

ADVANTAGES AND LIMITATIONS OF INFRARED DIAGNOSTICS OF ATHLETES' ORAL TISSUES

Until the end of the 20th century, sports medicine lacked reliable methods of non-contact thermometry of tissues in the oral cavity in athletes. But, at the beginning of the 21st century, owing to the introduction of high-precision thermal imagers, it became possible to study the dynamics of the local temperature of teeth, gums, tongue, palate, and dental constructions in the open oral cavity using infrared thermography. Initially, it was possible to measure the temperature of only the front teeth and gums in the vestibule of the oral cavity and only in the area of the anterior surface.

But then, it was shown that the implementation of infrared thermography using a dental mirror allows you to measure and record the local temperature of the back side of the surface of the teeth and gums, as well as the surface of the palate [44]. Thanks to this, very soon, free gingiva, attached gingiva, teeth, and alveolar mucosa were identified on thermal images. There were differences in temperature between teeth, free gingiva, attached gingiva, and alveolar mucosa.

Today, thermal imagers have appeared and infrared diagnostic technologies have been developed that allow recording the dynamics of the local temperature of any part of the human body surface in a large range of ambient temperatures, including cold weather and frosty days [14]. For such studies, FLIR thermal imagers are recommended, which provide local temperature recording with an accuracy of at least 0.01 °C [45].

At the same time, it is possible to obtain information not only about the temperature of the selected surface, but also about the local temperature of the tissues located under it at a depth of up to 1.5 cm from the studied surface [18]. Infrared study of the dynamics of the local temperature in the area of the athlete's head can be carried out without physical contact with him from a distance of several meters, so it does not affect the breathing and sports results of the athlete [40]. The only limiting factor is the visibility of the surface under study. In this regard, the thermal imager allows you to record the temperature of the oral cavity tissues only during the period when the athlete opens the oral cavity.

PATHOGENESIS OF TOOTHACHE CAUSED BY INHALING COLD AIR

Until now, dental constructions were traditionally installed on the teeth in the "summer" version. However, in recent years, there has been a need for "winter" dental constructions for thermal insulation of teeth when inhaling cold air in frosty weather through an open mouth. This is due to the development of sports competitions in winter sports and the development of territories in the northern latitudes [14]. Since when you inhale cold air through an open mouth, it is the teeth that are cooled first and most strongly, then, first of all, it is necessary to keep the heat in the teeth. Obviously, to do this, you need to cover the teeth with a heat-insulating material. It is also obvious that the thermal insulation of the teeth should have a good aesthetic result, namely, to preserve the natural appearance of healthy teeth [42, 46]. However, such a dental device is not yet included in the list of winter clothing.

In these conditions, in order to avoid cold toothache and the destruction of tooth enamel in the cold, polar explorers, hunters and military personnel use warm scarves, face masks and special balaclavas that cover their mouths. However, it is obvious that such closing of the mouth makes it difficult to breathe, so it reduces performance and is not suitable for highly qualified athletes.

Therefore, in the frosty air, athletes do not need a scarf, a face mask or a balaclava, but a special device for warming the teeth in the oral cavity. Modern braces, which are installed on the dental rows, also do not warm the teeth in cold weather. In addition, braces have a local irritant effect on the inner surfaces of the lips and cheeks. Unfortunately, until today, there are no generally accepted devices for thermal insulation of athletes' teeth. In this regard, during sports competitions and training in the cold, athletes may experience cold toothaches and cold damage to the tooth enamel. Therefore, in extreme cases, scarves, masks and balaclavas are used, which can partially warm the inhaled air, but they reduce sports performance.

Therefore, the presence of braces on the dentition of athletes during training and sports competitions in the cold does not prevent the occurrence of cold toothache and cold damage to the tooth enamel, and very warm winter clothing and a very warm winter scarf reduce athletic performance. At the same time, it has long been known that high sports results can be obtained by inhaling fresh air with a full chest through an open mouth. Therefore, despite the cold and the risk of frostbite, skiers, biathletes and skaters, even in severe frost, swallow cold air through an open mouth.

However, cold damage to the teeth when inhaling frosty air for a long time did not attract the attention of researchers. In turn, it should be recognised that braces, dental crowns and implants are still made of metal or ceramic with high thermal conductivity. Therefore, in frosty weather, braces, dental implants and dental crowns can still play the role of a "refrigerator" for the teeth of athletes engaged in winter sports. In this regard, healthy teeth have a higher resistance to local cooling when inhaling cold air through an open mouth than damaged teeth and teeth with fillings, crowns and braces. It is known that local cooling of the tissues thickens the blood in them, causes vasospasm and a feeling of pain. Therefore, cooling reduces the flow of warm blood to the cooled area of the body, which contributes to their deeper cooling [11].

It has been shown that the initiation of the pain sensation experienced following the thermal stimulation of dentine has been correlated with fluid flow in the dentinal tubules [9]. Deformation of the pulp chamber was observed before a noticeable temperature change was recorded at the dentine-enamel junction. Tubule deformation leads to changes in fluid flow more rapidly than fluid expansion or contraction.

In addition, some people may have a toothache after they stop being in the open air, that is, after returning to the room conditions. The fact is that, in some athletes, toothache can be caused by a violation of the adaptation of the pulp tissue in the damaged tooth to temperature changes [17]. This can be manifested by repeated episodes of diffuse, dull and pulsating toothache, which develops when returning to room temperature after a long stay in the cold. Episodes of such pain can last up to several hours. It is shown that screening the pulp tissue of the damaged tooth by increasing the protective layer of the dentin/enamel complex reduces the likelihood of developing such a pain syndrome. It is believed that such a tooth pain develops as a result of the fact that nociceptive C-fibres become sensitised and sensitive to harmless temperature gradients, since the threshold for activation of specific TRP ion channels decreases and central sensitisation occurs [17].

Therefore, cold toothache in different people may have different pathogenesis, but in all cases, the cause of the pain is a physical decrease in the temperature of the "sensitive" tooth. So, it can be assumed that the thermal insulation of the teeth when going out into the cold and inhaling cold air through the mouth will preserve the temperature of the dental pulp, prevent cold spasm of the blood vessels in the tooth pulp, eliminate mechanical compression of the pain receptors located in the walls of the blood vessels of the dental pulp, and prevent tooth pain. And finally, there is no doubt that the thermal insulation of the teeth will eliminate the temperature deformation of the tooth enamel.

DEVICES AND METHODS OF THERMAL INSULATION OF TEETH

Historically, the "Method of splinting braces" was developed first (RU Patent 2437632). The patent for this invention was granted in 2011. This technology was originally intended to protect the lips and cheeks from the irritating effects of braces. The essence of the method is that splinting braces is carried out using a low-melting material that hardens at a temperature of +30 - +35 °C. For this purpose, you can use, for example, beeswax. The pre-selected material is heated to +42 °C, then the molten material is poured into a syringe.

A needle with a blunt working end bent at an obtuse angle is attached to the syringe. After that, the person opens his mouth and, in this state, his braces and the outer surface of the teeth are dried with a stream of air. The person is placed face up, the head is turned until it takes a position in which the surface of the extreme tooth with the bracket system is located in a horizontal plane. After that, the molten material is squeezed out of the syringe onto the surface of the teeth until the bracket system placed on them is completely covered.

After the first link of the bracket system, filled with molten material, slowly turn the head of a person, sequentially bringing each next open tooth with a bracket to the horizontal position with simultaneous continuous squeezing of the molten plastic material from the syringe on each of them until it completely covers the bracket system. At the same time, a roller is formed from the hardened material, completely hiding the bracket system and protruding above its outer surface. After the material is completely solidified, a plaster model of the dentition with braces and a roller above them is made using the traditional method, after which a regular dental mouth guard is made using this model. This ready-made mouth guard can then be temporarily installed by a person on their own dentition at will, at any selected time, and for any period, including for the duration of the person's stay in the cold.

However, the use of such a dental mouth guard has several disadvantages. First, such a mouth guard worsens the aesthetic result, as it increases the volume of the lips in a person, which spoils and changes the expression of his face. Second, such a mouth guard spoils the appearance of the teeth. Moreover, the usual dental mouth guard does not have a tooth pattern. Third, such a dental mouth guard does not have a strong attachment to the dentition, so it eliminates the wide opening of the oral cavity, as it can fall out of the mouth. And, finally, such a mouth guard worsens breathing. Therefore, such a mouth guard is not suitable for use by highly qualified athletes during sports competitions and training.

A few years after that, it was proposed to use a regular plastic film instead of a mouth guard [42]. But this proposal also has significant drawbacks. In particular, the film requires multiple splinting braces with a fusible material, since this material can be easily removed when consuming hot food or hot water. In addition, such a film does not have a strong attachment with a roller, which is made of a low-melting material. Therefore, an athlete during an active inhalation or exhalation may accidentally remove the film from the surface with a stream of air. As a result, a detached piece of film can get into the athlete's larynx and cause asphyxia or it can fly out. In both cases, the previously insulated surface of the teeth remains bare.

Then, in 2018, decorative sticker on the dentition with splinted braces was patented (RU Patent 2654568). The decorative sticker on the dentition with braces contains an adhesive layer covered with an anti-adhesive film on the lower surface, a substrate on which a colour pattern is applied that does not change colour during operation, and a transparent coating on the top. The sticker is made of edible materials in the form of a ribbon with a thickness of 0.01-0.02 microns and a width of 9-12 mm.

The substrate is opaque, placed between the adhesive layer and the transparent coating, and the front side of the substrate is tightly covered with a transparent coating. The drawing is made in the form of sequentially arranged 3D images of the visible front surface of the upper and lower dentition of a healthy person in full size and covers the entire area of the substrate.

Between the adjacent images of the dentition, incisions are made in the form of a dotted line, located across the tape and allowing the tape to completely break across. The adhesive layer provides adhesion to hard and soft tissues of the oral cavity.

It should be noted that the tape can be made in the 3D version of the image of either the upper tooth row or the lower tooth row, or the upper and lower tooth rows, placed alternately, one after the other on the tape. It should be added that, in the initial state, the tape can be stored and transported in a state in which it is wound on a coil with a large reserve of working sections.

Figures 1, 2, 3 and 4 schematically show a decorative sticker on the dentition with splinted braces. In the initial state before the separation of the selected segment, it is a ribbon 1 which, in the initial state, is wound on a coil 2 and is designed to apply it either only to the upper or only to the lower dentition, or both, since it contains the corresponding images 3, located one after another with the presence of through notches 4 between them in the form of a dotted line located across the tape. The decorative sticker is made in the form of a ribbon, the front side of which has a transparent coating 5, covering an opaque substrate 6, under which there is an adhesive layer 7.

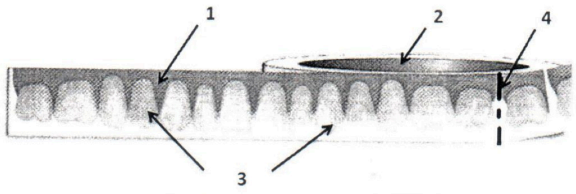

Figure 1: Decorative sticker in its original state

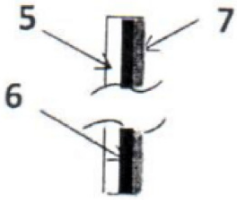

Figure 2: Cross-section of a decorative sticker (scale 1: 600)

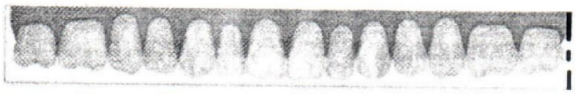

Figure 3: A segment of a decorative sticker torn from the main roll. On the tape - a panoramic 3D image of the upper dentition.

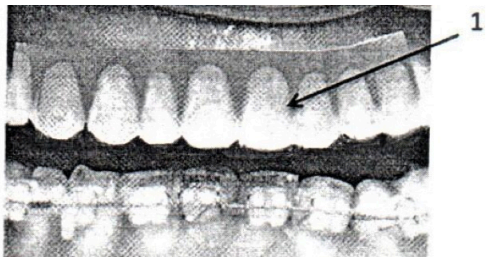

Figure 3: Decorative sticker pasted on the upper dentition.

This sticker is a brand new dental device. It very effectively protects the inner surface of the lips and cheeks from the irritating effect of braces, and also provides a very high aesthetic result, since it perfectly masks braces and imitates natural teeth. But this decorative sticker turned out to be "summer", not "winter", since it did not have a layer with thermal insulation properties. Therefore, it is not intended to effectively protect the teeth from cold damage during intensive inhalation of frosty air through the mouth, especially by athletes during sports competitions and training. In this regard, to give the thermal insulation function, the decorative sticker was improved. And in 2019, a patent was issued for the invention of a decorative sticker for thermal insulation of teeth (RU Patent 2698349). The essence of this innovative device is that the decorative sticker for thermal insulation of teeth is made of edible materials in the form of a tape. This tape consists of several layers. The adhesive layer is at the bottom. It provides adhesion to hard and soft tissues of the oral cavity and is covered with an anti-adhesive film. A layer of opaque substrate is placed on top, on which, in turn, a layer of transparent coating is placed. At the same time, a colour pattern is applied to the upper surface of the substrate, which does not change colour during use. This drawing is made in the form of consecutive panoramic 3D images of the visible front surface of the upper and/or lower teeth of a healthy person, completely in full size. Between the adjacent images of the teeth of the lower and/or upper jaw on the tape, notches are made in the form of a dotted line. These notches are located across the tape and provide a transverse break in the tape. In this case, the entire length of the tape is completely wound on the spool. It should be added that the sticker is made of materials that are not wetted by saliva and do not absorb it, and which are stored before, during and after blowing air at a temperature of +37...-80 °C. The sticker does not have a local irritant effect on soft tissues and a local destructive effect on tooth enamel and dentin. The tape has a width of 13-18 mm; inside the tape, along its entire width and length above the adhesive layer, there is a layer of food-grade gold foil. Above the foil layer, half the width of the tape and along its entire length, there is a layer of insulation with a thickness of 0.5-1.0 mm, made of thermal insulation material, above the layer of which and over the entire surface of the tape there is a layer of white substrate. The drawing occupies half the width of the tape above the thermal insulation layer and is made with the necks of teeth pointing towards the edge of the tape. A half of the width of the tape, free of thermal insulation, has a thickness of 0.11-0.12 microns. The developers of this decorative sticker, designed to insulate teeth in frosty weather and to preserve the pattern of natural teeth, offer the following method of applying the sticker. The device is used as follows before going out into the cold to perform long-term intensive physical work in the open air at the limit of their capabilities, for example, in connection with the participation of a biathlete in sports competitions in some particularly critical periods, for example, during TV shows, during photo- and video filming. The fact is that inhaling cold air with an open mouth can cause some people to feel aches and pains in the teeth, worsen the mood and reduce their performance. To avoid these complications, the sportsman goes to a pharmacy, selects a decorative sticker for thermal insulation of teeth, selects a sticker with the "right" width of the tape with the help of a pharmacist and buys it. Then the athlete brushes his teeth and wipes the surface on the selected row of teeth dry. After that, he removes the selected segment of the decorative sticker from the roll and applies it to the alveolar surface of the corresponding dentition with the correct location of the tooth pattern, namely, with the tooth necks directed towards the gums. Then, he straightens and aligns the tape, tightly presses the thickened half of its width to the teeth along the entire length of the dentition. After that, the athlete bends a thin half of the width of the sticker on the chewing and internal oral surfaces of the teeth, spreads the tape over the selected surfaces and presses it tightly to them. These steps ensure that the sticker is securely attached to the hard and soft tissues of the dentition. After that, the athlete can safely go out into the cold and can breathe cold air through an open mouth, without fear of the appearance of cold toothache and cold destruction of tooth enamel, since his teeth will remain warm despite the frosty air, just as his hands will remain warm in the cold when they are inside winter mittens.

CONCLUSION

During participation in sports competitions and training on a frosty day, athletes are often forced to breathe with their mouths open. At the same time, a stream of cold air enters the oral cavity, which causes the teeth to cool. It is established that periodic repeated cooling of the teeth damages the tooth enamel and, in some cases, causes severe toothache in athletes, which can sometimes persist for up to several hours even after returning to a warm room. It is shown that the thermal imager records the dynamics of the local temperature of the hard and soft tissues of the oral cavity, including artificial crowns and braces, regardless of the ambient temperature. Currently, the list of sports injuries does not include cold injuries of teeth and cold toothache, and the list of winter sports clothing and winter sports equipment does not contain special decorative stickers on teeth that exclude cold injuries of teeth during sports competitions and training of athletes in the cold. At the same time, thermal insulation stickers that provide thermal insulation of teeth when inhaling frosty air are known in the world. It is necessary to continue research on this problem in order to introduce "winter" decorative stickers in sports practice for reliable thermal insulation of teeth and complete exclusion in the future of cold damage to tooth enamel and the development of cold toothache in athletes engaged in winter sports.

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DEKORATIVNE NALJEPNICE ZA ZUBE: TERMALNA IZOLACIJA ZUBA SPORTISTA TOKOM TAKMIČENJA I TRENINGA NA HLADNOM VREMENU

Tokom sportskih takmičenja i treninga na otvorenom na hladnom vremenu, sportisti često izvode maksimalnu moguću fizičku aktivnost koja zahtijeva mnogo kisika. Povećana potreba za kisikom prisiljava sportiste da brzo udišu hladan zrak punim plućima kroz otvorena usta. Udisanje hladnog zraka kroz otvorena usta vodi ka lokalnom hlađenju zuba. Stepen i trajanje lokalnog hlađenja zuba se povećava sa povećanjem mraza, vjetra i snježnih padavina, uz povećanje trajanja udisanja hladnog zraka kroz otvorena usta. U isto vrijeme, lokalno hlađenje zuba može prouzrokovati njihovo oštećenje usljed hladnoće, a što je praćeno zuboboljom. Karakteristike patogeneze ozljeda zuba usljed hladnoće i zubobolja uzrokovana temperaturom tokom lokalnog hlađenja na hladnom vremenu su opisani na osnovu modernih podataka pronađenih u literaturi. Kako bi se održali visoki sportski rezultati, očuvalo dobro raspoloženje i zdravlje sportista, a posebno integritet i sigurnost njihovih zuba tokom zimske sezone, preporučuje se izolacija zuba korištenjem posebne dekorativne naljepnice. Pokazano je koje se karakteristike trebaju uzeti u obzir za termalnu izolaciju zuba kod sportista u normalnim uslovima, kao i uz prisustvo ortodontskog aparata. Članak opisuje suštinu modernih dekorativnih naljepnica koje su namijenjene za termalnu izolaciju zuba u uslovima udisanja hladnog zraka na hladnom vremenu. Svrha ovog rada je dati praktične preporuke za pripremu treninga i sportskih takmičenja na otvorenom tokom zimske sezone.

Ključne riječi: sportski trening, hladni zrak, zubi, karijes, prevencija povreda

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PAIN, INFLAMMATION AND PERFORMANCE CAN PREDICT THE IDEAL MOMENT TO APPLY NEW OVERLOAD

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ABSTRACT

Overloads must be applied to develop physical performance; nevertheless, despite the fact that the literature affirms that the proper moment to apply new loads is after recovery of physical performance, the metabolic markers underlying these observations remain poorly explored, and their metabolic bases remain obscure. Therefore, the objective of this study was to determine the ideal moment to apply new overloads based on pain and levels of inflammatory and biochemical markers. Forty volunteers were subjected to three days of experiments. After taking anthropometric measurements, the volunteers participated in an exercise programme applied between the experimental days. Data were collected using the McGill Pain questionnaire, shuttle run for VO_2 Max determination and as an intervention strategy, a 50-m test to determine the speed, and a one-repetition maximum to measure muscle force, as well as biochemical and immunological parameters. We found that exhaustive exercise caused significant elevations in levels of acute inflammation, including interleukin-6, tumour necrosis factor-alpha, interleukin-17a, and C-reactive protein, associated with pain and decreased performance. All these effects tended to normalise within two weeks and correlated with the time-course of decreased aerobic performance and muscle force output. We conclude that overload provokes acute inflammation, stimulating inflammatory markers, causing muscular pain and consequent decrease in athletic performance; nevertheless, after fifteen days, all values returned to baseline, suggesting that new overloads could be applied at the end of this process.

Keywords: exercise programme, exercise overload, exercise-induced inflammation, exercise biochemistry

INTRODUCTION

The pain-related muscle damage, inflammation and performance decrease (Christensen et al., 2018; Mohr et al., 2016) are three of the most important markers of muscle lesion, and metabolic impairment provoked to high-intensity exercise regime to improve the performance in athletes of world-class level. So, in these context, repetitive forceful muscle actions have been implicated in the aetiology of exercise-induced muscle damage and are typically accompanied by marked deteriorations in performance (Chatzinikolaou et al., 2014) delayed-onset of muscle soreness as a result of mechanical stresses imposed on myofibres, calcium homeostasis disturbances associated with transient inflammatory responses characterised by muscle edema (Nosaka et al., 1991), leukocyte infiltration into myofibres, and increased levels of cytokines and reactive oxygen species levels associated with local muscular pain (Cleary et al., 2002; Ferreira et al., 2016).

Maximal physical performance after a single exercise session depends on optimal organic conditions because increased muscle damage and inflammation could negatively affect sporting performance (Ferreira et al., 2016). Repetitive overloads result in accumulated fatigue, associated with increased risk of overtraining, injury and performance deterioration [6]. If recovery is inadequate, muscle damage-induced soreness, loss of function, decreased rate of force development and longer reaction times adversely affect performance and predispose athletes to injury (Michailidis et al., 2013). These phenomena provoke two questions: (I) when is the ideal moment to add new overloads? and (II) what biochemical and immunological markers could lend support to behavioural observations?

Exercise science guidelines suggest that the best moment to add new overloads to training is when physical performance improves over baseline, mediated by super-compensation [8]. However, this moment is a behavioural observation that needs to be supported by biochemical and metabolic markers evidence so as to allow the quantification of metabolic status prior to adding loads. So, inflammatory cytokines could be a very good support to these observations. Blood tests can be used when one wants to improve the precision of establishing the training progress, identifying the weak points of training programmes, and evaluating the possibility of lesions. To perform an effective, high-intensity training programme, it is important to correctly monitor biochemical blood tests so as to precisely oversee metabolic responses to training overloads (Seshadri et al., 2019).
If overloads are not well-calibrated, two problems might arise: (I) diminished or absent performance development or, more critically, (II) performance decrements and/or pathological sequelae as overtraining ("Essentials of Strength Training and Conditioning, 4th Edition," 2016). Overtraining, a process related to decreasing performance, increased pain, inflammation, and imbalance of exercise and recovery induces musculoskeletal trauma, increasing the production and release of pro-inflammatory cytokines, primarily interleukin 6 (IL-6), tumour necrosis factor-alpha (TNF-alpha), and interleukin 1- beta (IL-1β), all of which interact with various organic systems, initiating most of the signs and symptoms associated with performance decrement (da Rocha et al., 2019) and, sometimes, to pathogenic processes ("Essentials of Strength Training and Conditioning, 4th Edition," 2016). These observations could be critical to the athletic training.

Knowledge of the ideal moment to impose new physical training overloads is essential to maximise athletic performance. Accomplishing this task while avoiding overtraining highlights the importance of this study. We explored the relationship of biochemical markers of muscle injury and systemic inflammation, as well as muscle damage and performance impairments so as to determine the ideal moment to apply new overloads based on serum markers and pain levels.

MATERIALS AND METHODS

Participants

Forty volunteers of both genders completed the study after giving informed written consent. All participants did not engage in physical exercise or sports regularly. No participants showed lesions or conditions associated with acute inflammation or chronic disease prior to the study, and none were taking anti-inflammatory drugs for at least one month prior to or during the study. Finally, they were required not to participate in another exercise programme for at least fifteen days prior to the study onset. This project was approved by the National Health Council under the number of CAAE 44907715.2.0000.5653 on 27/07/2015, and it followed all ethical requirements. All participants gave an informed consent form in agreement with the Brazilian Ethics Committee.

Experimental design and familiarisation

Forty volunteers were subjected to three days of experiments; first day (P1), second day (P2), and third day (P3). After taking anthropometric measurements (P1), blood collection for biochemical and immunological parameters assessment was performed (P1). The volunteers participated in an exercise programme applied between the experimental days. Data were collected using the McGill Pain

(P1) questionnaire, shuttle run for VO_2 Max (P1) determination and as an intervention strategy, a 50-m test to determine the speed (P1), and a one-repetition maximum to measure muscle force (P1). All collections and measurements were performed one (P2), and two (P2) weeks after the beginning of the proposed experimental exercise intervention.

Before the data collection, procedures of familiarisation were performed. The participants arrived at the location of data collection at the same time of day as the subsequent experimental sessions (in the morning between 9:00 and 10:00 am) and cycled on an ergometer for 5 minutes at an intensity that resulted in a heart rate of around 120–140 bpm, followed by a general upper body warm-up. Next, the participants were subjected to all physical tests five times until their performance did not differ from the last time. Finally, 30 days of rest were imposed before the first day of data collection.

This procedure was performed 30 days before the beginning of the experimental physical training to avoid interference of this procedures in the pain level, biochemical and immunological outcomes.
Heart rate and blood collection were acquired after the exercise to determine the acute effects on biochemical and immunological variables. On days 2 and 3 of collection, a peripheral blood sample was obtained before and after the shuttle run for biochemical evaluations, and 24 hours after the end of the exercise section, new blood collection for immunology was obtained. Then, a new 1RM test, a maximum velocity test and the McGill questionnaire were administered. The heart rate was obtained in real-time throughout cardiac monitoring using the cardiac monitor. Blood samples for quantification of lactate were carried out immediately after the end of the exercise. All data collection lasted two weeks. The scheme of data collection is displayed in Figure 1.

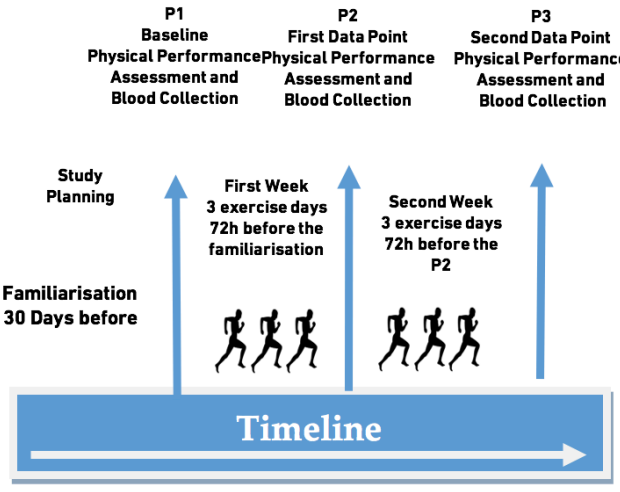

Figure 1: Data Collection Scheme

Blood collection was acquired before and after the experimental exercise intervention.

Anthropometric parameters, physical performance and blood

Anthropometric characteristics
Age, body mass, stature, and speed were measured using pattern tests (Table 1). Body mass index (BMI) was calculated using Equation 1. VO_2 Max was calculated using the shuttle run test (SRT) with Equation 2 (See "Determination of the Maximum VO_2"). Body mass and stature were obtained using a mechanical scale and stadiometer (Filizolla, Brazil) with a precision of 0.1 kg and 0.1 cm, respectively.

$$BMI = \frac{\text{Body mass}}{(\text{Stature} \times \text{Stature})}$$

Equation 1: Body Mass Index Equation

Table 1: Volunteer Characteristics of Participants

Age (y)	20.6 ± 1 .72
Body Mass (Kg)	66.6 ± 3.08
Stature (cm)	1.72 ± 0.1
BMI (Kg/m²)	22.5 ± 1.7
VO_2 Max (ml·kg^{-1}·min^{-1})	32.2 ± 2.64
VO_2 Max (ml·min)	1.60 ± 0.4

Legend: (Kg = Kilograms; cm = Centimetres; BMI = Body Mass Index; Kg/m2 = Kilograms per metre squared; VO_2 Max = Maximum Oxygen; ml·kg^{-1}·min^{-1} = millilitres per kilogram per minute; ml·min = millilitres per minute).

Short Form of McGill Pain Questionnaire-2

The short-form McGill Pain Questionnaire-2 (SF-MPQ-2) was used to record pain data. SF-MPQ-2 is an expanded, revised version of SF-MPQ that includes seven relevant symptoms for neuropathic pain and uses a numerical scale from 0 to 10 (NRS) as well as a verbal scale with 22 items, each representing different qualities of pain and its related symptoms.

Three of these subsections were sensorial pain descriptors and the fourth one consisted of an emotional descriptor of pain as follows: (1) continuous pain (six items); (2) intermittent pain descriptors (six items); (3) predominantly neuropathic pain descriptors (six items); (4) psychological descriptors (four items).
The mean of the four subscales and the 22 total

items were individually calculated and then, only the total mean of the four items was considered. A higher score indicated a higher prevalence of pain symptoms. Mean pain intensity and muscle pain intensity index were rated on a 0–10 scale (NRSs); the scale allowed an overview and stratification of chronic or clinical pain. The administration of the questionnaire followed the procedures previously described by Melzack (Melzack, 1987) and was revalidated for Brazil and for the Portuguese language by Da C. Menezes Costa et al(Da C. Menezes Costa et al., 2011) . The scale shows that, when the subject relates zero (0), it signifies no pain, when it is one (1), it signifies mild pain, when it is two (2), it signifies moderate pain, and when it is three (3), it signifies severe pain.

Exercise protocol and data collection procedure

The 1-rep-max (1RM) and the maximum speed tests were performed seventy-two hours before the first day of data collection. A peripheral blood sample was obtained by venepuncture for lactate quantification and immunological parameters, and the McGill questionnaire was administered on the first day of experiments, immediately prior to the shuttle run test.

Determination of physical performance and VO_2 Max

The shuttle run test [14] that creates a situation of progressive exercise to the point of maximum exhaustion, thereby fulfilling the requirements for measuring the two factors determining physical performance, was used. To carry out this test, we used a space of 25 meters, a computer, audio test, 10 cones, tape measure, and stopwatch, a scoreboard with a number of turns, note sheets, and heart rate monitors. This test was applied to groups of five, who ran together along with an audio rhythm covering a space of 20 meters, previously delimited between two parallel lines. The audio beeps were set up at predetermined time intervals, progressively decreasing within each stage of the test.

The idea was to force the path to be fulfilled in progressively less time, thereby increasing the intensity of the test until exhaustion was achieved. In this way, the runner would pass through the finish line with at least one of the feet before each beep; if he could not cross that line twice consecutively with one of his feet, the test was interrupted and the results noted. Velocity was used to enter an equation that was provided in the test protocol in order to calculate the maximum VO_2 (Tomkinson et al., 2017). At the end of the test, the number of turns corresponds to the speed reached in the test. In order to determine the speed by the number of turns, it is necessary to consult a table provided in the test protocol. Subsequently, the registered speed is entered into an equation that is also provided in the test protocol to calculate the maximum VO_2 (Léger et al., 2017).

$$Y = -24.4 + 6.0\,(X)$$

Equation 2: Equation 2: Shuttle Run Test Equation Y = VO_2 in ml/Kg/min; X = Speed at Km/h (in the target stage)

Determination of maximum speed

To measure maximum speed, the 50-meter velocity test was used. This involves a single sprint of 50 meters, with the time being marked with a stopwatch. A warm-up, including the practice of free movements, stretching and small accelerations of up to 5 meters were performed before the test.

The test started from a stationary standing position where the hands cannot touch the ground and feet are uneven - one slightly in front of the other - where the front foot should be behind the starting line. Once the subject is ready and immobile at the appropriate starting place, the evaluator will give two commands. The first to alert him to the proximity of the beginning of the test and the second intended for starting the test.

The evaluator should encourage the participant with verbal stimuli so that the subject is encouraged to keep pace and not slow down before the finish line (Young et al., 2001). All verbal stimuli were standardised to all participants. Immediately after the middle, the evaluator would pronounce "GO, GO, GO!" in a high voice.

Heart rate

The heart rate was determined immediately after the end of the test using the FTI model Polar heart monitor.

Determination of muscle strength

To quantify quadriceps strength, a lower limbs extensor chair was used. The subject performed a leg extension in an extension chair with the knee flexed at 90° (full extension = 0), with the contact location of the arm of the equipment resting on the distal end of the tibia, quite close to the malleolus. These procedures were previously described by (Macht et al., 2016).

The maximal repetition test (1RM) was used in the lower limbs extensor chair, in order to determine the maximum isotonic strength of the quadriceps.

The standard protocol of the 1RM test was used as described by the National Strength and Conditioning Association (Macht et al., 2016).

The volunteer performed mild warm-up with low resistance in the apparatus so that they completed 5 to 10 repetitions with ease. After 1 minute of recovery, 5 to 9 kg were added, and the volunteer completed 3 to 5 repetitions. If completed, a new recovery time of five minutes was achieved and again 5 to 9 kg were added, and if the subject was able to complete 2 to 3 repetitions, a new round of five minutes of recovery was completed and a new load of 5 to 9 kg was added. This process was followed until the subject could not complete more than one repetition as the 1RM protocol suggests (Macht et al., 2016).

Collection of peripheral blood samples

After the blood was drawn (see the data acquisition scheme; Figure 1), it was centrifuged at 1200 RPM for 5 minutes to separate cells from serum. The serum was used for quantification of lactate dehydrogenase (LDH), creatine kinase (CK-MB), total creatine kinase (CPK), C-reactive protein (CRP), lactate (LAC), total bilirubin (BIL), aspartate aminotransferase (AST), alanine aminotransferase (ALT), gamma-glutamyl transferase (GGT), alkaline phosphatase (AP), amylase (AMI), and lipase (LIP). These parameters were measured using the Konelab, Model 60i automatic device with Wiener branded laboratory kits, following the equipment protocol. The device was calibrated according to the manufacturer's recommendations. All experiments were performed in duplicate.

Quantification of cytokines

All reagents used were obtained from the Human Cytokine Kit (Becton Dickinson Biosciences, San Jose, CA, USA) for Th1, Th2, and Th17 cytokines. The cytometer was calibrated according to the manufacturer's recommendations. Standard curves were calibrated for each cytokine (0.00 to 5000 pg/mL), and the samples were analysed using FCAP Array Software (Becton Dickinson, San Jose, CA, US). Values were reported as pg/mL. All samples were assayed in duplicate.

Statistical analysis

The descriptive data were expressed as mean, percentage and standard deviation. To determine the normality of the data, the Shapiro–Wilks test was performed, and the data were considered as no normal. Then, the Kruskal–Wallis with Dunn's posterior test was used to determine the difference between the days of experiments. Finally, the Spearman correlation test was used to determine the correlation between the performance and pain variables. All tests had a significance of 95%. The entire statistical procedure was performed using Prism Stat 5.0.

RESULTS

The McGill questionnaire revealed increased levels of pain due to intense exhaustive exercise training According to the scale of the short-form McGill Pain Questionnaire-2 (SF-MPQ-2), when the subject relates "0" it signifies no pain, when it is "1", it signifies mild pain, when it is "2", it signifies moderate pain, and when it is "3", it signifies severe pain. The subjects reported no pain on day 1 prior to the exercise session. On day 2, prior to the exercise experiment, fifteen volunteers reported level 3 pain, two reported level 4 pain and one reported level 2 pain. On day 3, one volunteer reported level 0, thirteen reported level 1, and two reported level 2 pain (Table 2).

Table 2: McGill Questionnaire

McGill Questionnaire			
	Day 1	**Day 2**	**Day 3**
Level 0	100%		
Level 1			72.2%
Level 2		5.6%	16.7%
Level 3		94.4%	

Legend: Forty volunteers were subjected to 2 weeks of exhaustive short exercise, 3 times a week for 30 minutes per session. The McGill Questionnaire was used to confirm muscular pain. The questionnaire was applied prior to the shuttle run test.

Intense exhaustive intermittent exercise results in acute lower athletic performance
With respect to athletic performance, VO_2 Max levels were significantly lower on day 2 (Table 3) than on day 1. On day 3, no difference was found. The speed and 1 RM performance also significantly declined on day 2 (Table 3).

Table 3: Athletic Performance

Athletic Performance						
	Day 1		**Day 2**		**Day 3**	
VO_2 max ($mL \cdot kg^{-1} \cdot min^{-1}$)	32.2 2.64	±	29.2 3.56#	±	33.6 4.48	±
Speed (Km/h)	9.8 0.45	±	8.5 0.86*	±	9.9 0.38	±
HR Max (FC)	175 7.87	±	168 16.31*	±	185 7.21*	±
1 RM (Kg)	61 23.61	±	55 16.97*	±	60 19.05	±

Legend: Forty volunteers were subjected to 2 weeks of exhaustive short exercise, 3 times a

week, 30 minutes per session. The shuttle run test was used to measure the performance of exhaustive training and to assess the VO_2 Max levels. The Kruskal-Wallis with Dunn's Post Hoc at 5% of significance was applied in order to identify different results along the experiment. (*= p < 0.01 vs Day 1; # = p < 0.05 vs Day 1). Values are expressed in mean and standard deviation.

High correlation between physical performance and pain

A correlation displayed similar behaviour. On day 1, the correlations between pain, aerobic performance and muscle power were very high; on days 2 and 3, we observed large and significant correlations between aerobic performance and pain, although muscle power output was lower. There was a high correlation with pain on the three days investigated.

Table 4: Spearman Correlation Test Results

Spearman Correlation Test					
		Aerobic Performance vs Pain		Muscle Power Output vs Pain	
Day 1	EG	*r* = 0.91	*p* = 0.013	*r* = 0.89	*p* = 0.038
Day 2	EG	*r* = 0.89	*p* = 0.028	*r* = 0.83	*p* = 0.036
Day 3	EG	*r* = 0.83	*p* = 0.033	*r* = 0.78	*p* = 0.042

Biochemistry and tissue damage markers
Lactate dehydrogenase (LDH) showed higher values on day 2 than on day 1; however, it showed significantly lower values on day 3 (Table 4). CPK levels were also significantly greater on day 2 but significantly lower on day 3. Similarly, R-factor levels were significantly higher on day 2 but decreased equally by day 3 (Table 4). Maximal lactate values were significantly lower on day 2 than the initial values, and they significantly increased again on day 3. CRP levels were significantly higher on day 2 than on day 1, but they decreased by day 3 (Table 5).

Table 5: Biochemistry Markers of the Volunteers

Biochemistry Markers			
	Day 1	**Day 2**	**Day 3**
LDH (U/L)	302.6 ± 49.12	543.50 ± 23.22*	348.30 ± 27.15
CK-MB (U/L)	11.50 ± 2.58	11.90 ± 3.35	12.3 ± 3.38
CPK (U/L)	88.20 ± 31.17	93.40 ± 42.19#	90.50 ± 47.62
C-RP	1.20 ± 0.05	11.70 ± 2.36*	4.10 ± 1.98$,#
R-Factor	5.70 ± 1.58	10.20 ± 2.21*	6.50 ± 1.70
Lactate	13.70 ± 1.98	9.60 ± 2.30¢	13.30 ± 1.77

Legend: Forty volunteers were subjected to 2 weeks of exhaustive short exercise, 3 times a week for 30 minutes per session. Baseline data were registered prior to and 24 hours after the exercises. On day 1 (one week before the baseline) and day 2 (one week before day 1), blood sampling was carried out 24 hours prior to the exercise session. Values for lactate dehydrogenase (LDH), creatine kinase-MB (CK-MB), CPK (Total Creatine Kinase), C-RP (C-reactive protein), and R-Factor (Rheumatoid Factor) were monitored. The Kruskal-Wallis with Dunn's Post Hoc at 5% of significance was performed to identify the differences during the study. (* = p < 0.0001 vs Day 1, # = p < 0.05 vs Day 1, and $ = p < 0.01 vs Day 1 and Day 2). Values were expressed as mean and standard deviation.

Cytokines

The IL-6 values were greater on day 2 (38.49 ± 9.63 pg/mL) than on day 1 (1.62 ± 0.51 pg/mL) (p < 0.0001), and remained high on day 3 (14.37 ± 1.16 pg/mL) (p < 0.05) (Fig. 2A). TNF-α values were greater on day 2 (12.43 ± 2.08 pg/mL) than on day 1 (1.63 ± 0.24) (p < 0.0001), and remained lower on day 3 (2.82 ± 0.61), with no differences with day 1 (p > 0.05) (Fig. 2B). IL-17a showed higher values on day 2 (15.99 ± 1.78) than on day 1 (1.79 ± 0.4) (p < 0.0001) and on day 3. These values decreased significantly (p < 0.0001) but remained higher than those of day 1 (p < 0.0001) (Fig. 2C).

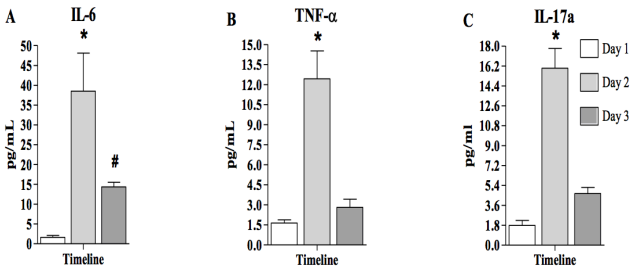

Figure 2: Inflammatory cytokines

Forty volunteers were divided into an Experimental Group (EG) and a Control Group (CG), and were subjected to exhaustive short exercise for two weeks, 3 times a week, 30 minutes per session. Baseline data were registered prior to and 24 hours after exercise performance. On day 1 (one week prior to the baseline) and day 2 (one week prior to day 1), blood sampling was carried out 24 hours prior to the exercise session. (A) Interleukin 6, (B) Tumor Necrosis Factor-Alpha and (C) Interleukin 17-a were measured. The Kruskal–Wallis with Dunn's Post Hoc at 5% of significance was used to identify the possible differences between the days. (* = p < 0.0001 vs Day 1; # = p < 0.05 vs Day 1).

DISCUSSION

The main results of this study were that exhaustive exercise causes inflammation, pain and increased levels of pro-inflammatory cytokines in sedentary people, resulting in decreasing performance. However, we found that inflammation regresses 15 days after initial training. To the best of our knowledge, the time-course of pain and performance associated with biochemical and immunological parameters have been poorly studied in the previous period with respect to giving guidance as to the ideal moment to apply new overload stimuli. The study was performed by 15 days because, in this time point, all values measured back to the baseline values.

The study is novel in that it focuses on associations of time-course behaviours with possible mechanisms that sustain these phenomena during the acute and sub-acute phase of the training. These display similarities with overtraining and pathological processes that result from accumulation of overly repeated training (da Rocha et al., 2019).

Our data regarding cytokine levels and inflammation indicated by biochemical and immunological data were consistent with the findings of da Rocha et al. (da Rocha et al., 2019), who showed that overtraining provoked damage in various tissues and organs with impairment of biochemical and immunological parameters associated with inflammation, increase in pain and decreased athletic performance. All these effects are also associated with overtraining; here, by contrast with overtraining or pathological conditions, continuation of the exercise programme did not cause more problems than the initial overload.

These effects, although consistent with overtraining, appeared at the beginning of the high-intensity exercise programme, representing a fundamental difference between the two cases. This understanding can be critical to the discussion because it could represent a different phenomenon than overtraining, which is a pathological process.

To decrease overtraining symptoms, physical training needs to be stopped, usually leading to normalisation of the biochemical and immunological markers and athletic performance. Nevertheless, here, the exercise programme was not stopped, and the symptoms decreased even after two weeks of exercise programme continuation, suggesting that this is a normal adaptation to exercise.

Pain is often associated with high intensity or duration of physical exercise (Pumpa et al., 2014). Delayed onset muscle soreness (DOMS) and muscle damage are commonly self-limiting; training-related conditions can result in loss of muscle force and significant pain (Cleary et al., 2002). For athletes who train and compete daily, DOMS can pose an obstacle to optimal performance.
In the present study, pain correlated with decreased aerobic performance and power output of the muscle group that suffered the greatest amount of pain. Samut et al. (Samut et al., 2015) found that an effective reduction in pain may improve function and muscle strength, and this is precisely what we confirmed in the present study. On day 1, volunteers reported no pain. On day 2, high levels of pain were reported, and aerobic and muscular performance decreased; however, on day 3, performance returned to its initial levels along with pain.

Accordingly, the maximal effort was lower on day 2 than on days 1 and 3, probably because of self-limitation related to the previously related pain. Cleary et al. (Cleary et al., 2002) are corroborated here by the lower heart rate and lactate concentrations found on day 2 than on those from days 1 and 3.

Biochemical marker behaviour may help to explain these results because we observed higher values for LDH and CPK on day 2 than on days 1 and 3. These biochemical tissue injury markers elevated on day 2 support the systemic inflammatory process and pain, as previously reported (Pearle et al., 2007). Nevertheless, biochemical parameters associated with various organs (liver, spleen and kidney) did not increase (data not shown), suggesting that these biochemical changes may be related to muscle injuries caused by exhaustive exercise and not to a pathogenic process.

Although the IL-6 levels can be related to metabolic answers to several conditions, including exercise or disease, the highest levels here were associated with high-intensity exercise, and the time-course observed before (Galassetti, 2010). Thompson et al. (Thompson et al., 2010) suggested that IL-6 levels may increase in exercise-induced inflammation, by contrast to the behaviour of other inflammatory markers such as CRP. These observations led to the suggestion that IL-6 behaviour can be a good inflammatory marker.

Declining levels of IL-6, together with those of other markers such as CRP, can indicate inflammation decreases, suggesting that this interleukin plays an important role in inflammatory/anti-inflammatory balance. Exercise is known to be a non-pharmacological treatment for pain, improving muscle strength and physical function (Ew & Medicine, 2010). Accordingly, with the continuation of physical training, we expected to record less pain, decreased inflammatory marker levels and better muscle function, as observed on day 3. Extrapolating these considerations, it can be

argued that in particular instances, the effects of some forms of exercise may become harmful, as described in a review by Cooper et al. (Cooper et al., 2007).

We showed pro-inflammatory cytokines kinetics as well as their relationships with the time-course of pain, inflammation and muscle function. Specifically, we focused on IL-6 that showed the highest correlation with acute and chronic exercise (Lira et al., 2017) and TNF-α, a pro-inflammatory interleukin related to tissue injury (Suzuki et al., 2002). Both showed the highest levels on day 2; however, TNF-α levels decreased on day 3. These data suggest the inflammatory effect of high-intensity exercise during the acute period (days 1 and 2); nevertheless, during a subacute period (day 3), both cytokine levels returned to baseline, suggesting that the inflammation imbalance caused by exhaustive exercise lasted fifteen days. IL-17a, a cytokine related to rheumatoid disease, showed increased levels, as did IL-6 and TNF-α. Together with R-Factor, this effect appeared to be caused by exercise intensity, ruling out a subsequent rheumatic disease. To confirm this, values of TNF-α and R-Factor on day 1 were within normal levels, expected for the absence of rheumatic disease that could have an influence on our data.
The data show that the high-intensity exercise induces inflammation and pain in the early stages of training; nevertheless, the continuity of training, the inflammatory state, pain, and performance impairment tends to normalise by fifteen days. It appears that intense exercise causes impairment in performance due to the inflammation similar to overtraining, probably mediated by the same mechanisms. Taken together, these data may help to explain the metabolic and immunologic mechanisms underlying adaptations during the early stages of high-intensity training.

CONCLUSIONS

Exhaustive exercise causes acute inflammation, followed by pain and performance impairment, confirmed by biochemical and immunological markers during the acute phase that revert to normal levels after fifteen days. This suggests that new overload charges could be applied fifteen days after the overload proposed and that the initial inflammatory process appears to be a natural process of adaptation and should be regarded as normal at this stage, within reasonable limits.

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BOL, UPALA I SPREMNOST MOGU PREDVIDJETI IDEALNI TRENUTAK ZA PRIMJENU NOVOG PREOPTEREĆENJA

Preopterećenja se moraju primijeniti kako bi se razvila fizička spremnost; ipak, uprkos činjenici da literatura potvrđuje da je pravi trenutak za primjenu novih opterećenja nakon oporavka fizičke spremnosti, metabolički markeri koji se odnose na ova opažanja su i dalje slabo istraženi, a njihove metaboličke osnove ostaju nepoznate. Prema tome, cilj ove studije je bio odrediti idealni trenutak za primjenu novih preopterećenja na osnovu boli i nivoa upalnih i biohemijskih markera. Četrdeset dobrovoljaca je podvrgnuto trodnevnim eksperimentima. Nakon antropometrijskih mjerenja, dobrovoljci su učestvovali u programu vježbanja koji je primijenjen tokom trajanja eksperimenta. Podaci su prikupljeni korištenjem McGillovog upitnika za bol, testa trčanja s ubrzanjima za određivanje VO_2 Max i u svrhu intervencijske strategije, testa 50-m za utvrđivanje brzine i jednog maksimalnog ponavljanja za mjerenje mišićne snage, kao i biohemijskih i imunoloških parametara. Otkrili smo da je iscrpljujuće vježbanje uzrokovalo značajno povećanje u nivoima akutne upale, uključujući i interleukin-6, faktor tumorske nekroze alfa, interleukin-17a i C-reaktivni protein, a koji su povezani sa boli i smanjenom spremnošću. Svi ovi efekti su imali tendenciju vraćanja u normalno stanje nakon dvije sedmice i bili su povezani sa trajanjem smanjene aerobne spremnosti i kapaciteta mišićne snage. Zaključujemo da preopterećenje izaziva akutnu upalu, a stimuliranjem upalnih markera prouzrokuje mišićnu bol i time smanjenje sportske spremnosti; ipak, sve vrijednosti su se nakon petnaest dana vratile na polazne, što ukazuje da se nova preopterećenja mogu primijeniti na kraju ovog procesa.

Ključne riječi: program vježbanja, preopterećenje tokom vježbanja, upala prouzrokovana vježbanjem, biohemija vježbanja

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FEAR IN THE WATER ENVIRONMENT AS A FACTOR INFLUENCING THE SWIMMING COMPETENCY OF SECONDARY SCHOOL STUDENTS

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ABSTRACT

Introduction: One of the factors that can significantly influence the swimming learning process is fear. Individuals can experience different types of fear, including a fear of swimming, fear of deep water and fear of drowning, which can, in the worst cases, result in panic attacks.
Problem and Aim: The purpose of this study was to examine the level of fear that students experience in relation to the water environment and the changes in that fear during a course of swimming lessons. In addition, we wanted to investigate how the parenting behaviours, such as overprotection, correlate with the students' fear in the water environment.
Methods: We used observation and a questionnaire to collect data. The sample consisted of 175 secondary school students. We used the Person correlation coefficient to measure the correlation between the fear level and the parental behaviour; and the paired t-test to determine if the fear level changed between the initial lesson and the final lesson of the swimming course.
Results: We found a statistically significant difference between the level of fear during the initial class and the final class in both genders ($p < 0.001$). The strongest correlation was recorded between the observable fear and the parental behaviour of rejection.
Conclusion: We found that the level of fear significantly decreases during a swimming course, which suggests that parents should leave their fearful children in the hands of professionals. Our assumption – that the parental behaviour of overprotection would have the strongest correlation with the subjects' fear – was not confirmed.

Keywords: fear, swimming lessons, parental behaviour, secondary school students

INTRODUCTION

Swimming competency is affected by a number of different factors: age, environment and facilities, as well as a number of anatomical, physiological and functional preconditions. Sport is also a strongly social phenomenon, so we cannot forget the sociological, economic and psychological factors that have an influence on swimming competency. One of the factors that can significantly influence the swimming learning process is fear. Barlow, Brown and Craske (1994) define fear as an immediate emotional reaction, characterised by strong escapist tendencies in response to a present danger or life-threatening emergency, where often there is a surge in the sympathetic branch of the autonomic nervous system.

Individuals can experience different types of fear related to the water environment, including a fear of swimming, fear of deep water and fear of drowning, which can, in the worst cases, result in panic attacks. According to Jursik (1993), fear significantly affects the central nervous system and the transmission of information from the receptors to particular organs. Thus, the water environment irritates the students' receptors and may instigate characteristic situations and behaviours. Bence and Virčík (2010) pointed out that fear of the water environment frequently prevents both male and female students from engaging in swimming and other water activities. These students cannot overcome this fear, and therefore they are not able to acquire fundamental swimming skills even after completing the swimming courses organised by their schools. As a result, they do not want to visit swimming pools or water parks, or even to simply be around the water. They do not want to engage in swimming and they do not consider swimming competency to be an important factor for their health or social existence. The results of Irwing (2015) also showed that children/adolescents with a substantial fear of drowning reported much lower levels of swimming participation. This finding supports the previous research that found a fear of drowning to be the variable to have the most significant impact on having no or low swimming competence (Irwin et al., 2008; Irwin et al., 2010; Irwin et al., 2009).In Ziara (2005), pupils who showed a higher level of anxiety, especially during their first swimming classes, achieved lower results in the consecutive tests of swimming skills. However, despite a gradual improvement in their swimming skills, the average level of anxiety in these children was reduced very slightly. It seems that their progress in learning to swim was based on the systematic repetition of a series of exercises, which (sooner or later) produced the desired effect of the acquisition of simple swimming skills. Nevertheless, it did not signify the relief of their anxiety and tension. However, this observation did not correspond with the findings of Muhamad et al. (2013), which showed that swimming effectively eliminated anxiety among university students and resulted in a continued decrease of tension. Similarly, Jánošková (2012) found that a regular, one semester participation in aqua aerobic lessons by female university students dramatically decreased the level of anxiety that the students experienced in the water environment. Poulton et al. (1998) examined the relationship between water trauma and water skills before the age of 9, and the presence of water fear and phobia at the age of 18 in a longitudinal birth cohort. They found no evidence of a relationship between water confidence and water trauma up to the age of 9, or the fear of water at age 18. Similar findings were obtained for a water phobia at age 18, with the exception that some study members who were less able to immerse themselves in the water with confidence at age 9 were more likely to report a water phobia at age 18. Graham and Gaffan (1999) conducted research on water-fearful children (non-swimmers, 5-8 years old) and adults (non-swimmers or late learners, 23-73 years old) who were compared with a non-fearful control group of a similar swimming ability. The parents usually believed that the children's fear was present at first contact with the water. Their finding also suggested that learning within the family decreased the likelihood of water fear rather than increasing it; when both the child and parent showed fear, this was as likely to reflect familial influences in the modelling. Young children's water fear forms a part of a generic cluster – fear of the unknown or fear of danger – while in adults, the fear becomes independent of generic fears.

PROBLEM AND AIM

The purpose of this study was to examine the level of fear that students experience in relation to the water environment and the changes in that fear during a course of swimming lessons. In addition, we wanted to investigate how the parenting behaviours, such as overprotection, correlate with the students' fear in the water environment.

MATERIALS AND METHODS

Participants

The sample consisted of 175 secondary school students from 7 different schools in the Košice region (94 male and 81 female students) who participated in the swimming courses. Each course was organised separately by their schools. The average age of the participants was 17.3 for the boys and 17.4 for the girls. From the original number of 188 students, we excluded 13 students, since they did not meet the conditions necessary to be included in our research (the questionnaire was not completed according to the instructions).

Observable fear checklist

The aim of this procedure was to examine the level of fear that the students experienced before and after completing the swimming course, in relation to the water environment. We composed a checklist of 10 common fear symptoms. The subjects were asked to perform each task included in the list.
Tasks to perform:
1. Enter the water
2. Hold your breath under water
3. Submerge your face
4. Blow bubbles
5. Push off the wall and float
6. Dry off your face
7. Open your eyes under water
8. Pick up an object from the bottom of the pool
9. Jump in the water

10. Dive in the water

Each task was assigned a particular score as follows: Failed – 0 points; Hesitated – 1 point; and Performed – 2 points. In the case of the "Dry off your face" item, we monitored if the student tended to dry off their face after coming out of the water and we scored this as follows: Excessively – 0 pts; Moderately – 1 pt; and Not at all – 2 pts. We performed this observation at the beginning and at the end of the swimming course, and it was administered by two independent observers. The scores of each subject in relation to all the tasks were added together, and where the score was closer to 0, we assessed the subject as more fearful; whereas if the score was closer to 20, we assessed the subject as less fearful or as eventually having no fear whatsoever.

sEMBU (shot version of a parental rearing style questionnaire)

The aim of this questionnaire was to investigate the preferred parenting behaviours among our sample. The results were subsequently correlated with the fear level recorded in the first lesson of the swimming course to find which parenting behaviour had the strongest correlation with a fear of the water environment. Each subject's questionnaire and observable fear checklist was coded so that we could pair them for the purpose of a statistical analysis. The EMBU is among the measures used most often for the assessment of adults' perceptions of their parents' behaviour. For the purposes of this study, we used the 23-item short version of the EMBU, which had previously been validated in the Slovak population (Poliaková et al., 2007). The sEMBU provides three subscale measurements: rejection, emotional warmth and overprotection. We instructed the subjects on how to fill in the questionnaire, and then asked them to complete it before the swimming courses had started.

Data analysis

We used MedCalc for Windows, version 15.8 (MedCalc Software, Ostend, Belgium) to conduct a quantitative analysis. The following types of graphs were used for the graphical presentation of the results: line graph and bar graph. We used the Person correlation coefficient to measure the correlation between the fear level and the parental behaviour; and we used the paired t-test to determine if the fear level changed between the initial lesson and the final lesson of the swimming course. In the probability calculations, the statistical significance was p = 0.05 at the 95% significance level, and p = 0.01 at the 99% significance level. In terms of the logical methods, we employed induction, deduction and causal analysis.

RESULTS

The average score for the observable fear in the initial lesson was close to 15 pts in both the female (13.29 pts) and male students (14.26 pts), which can be regarded as having little fear. During the last lesson, both genders scored 20 pts on average (boys – 19.7 pts; girls – 19.83 pts).

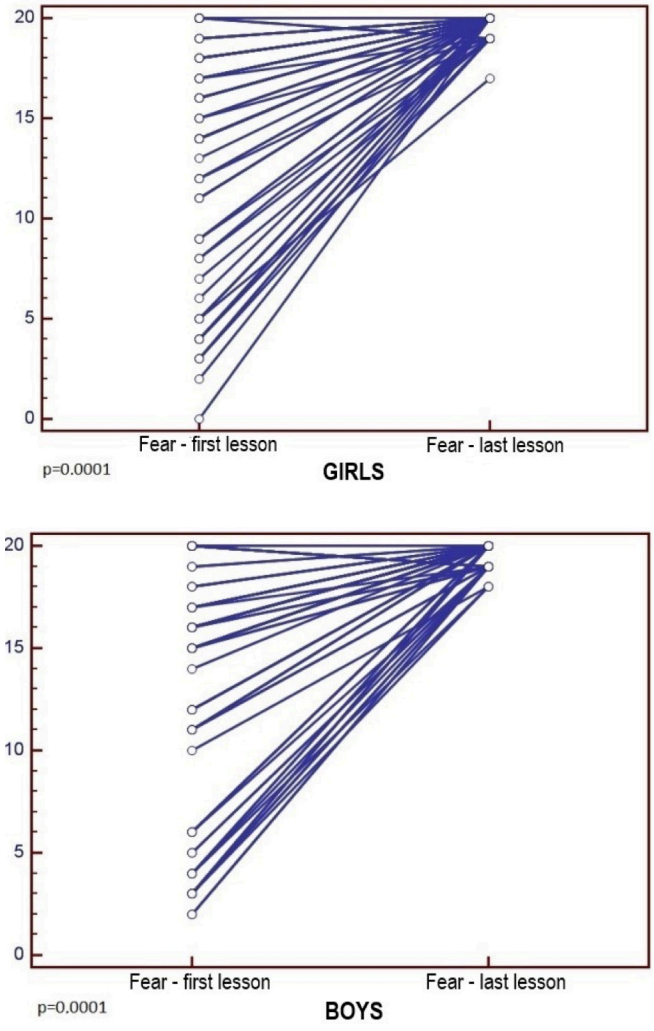

Figure 1: Observable fear score

Figure 1 shows the individual scores, of boys and girls, during the first lesson and the last lesson (each point represents an individual subject's score, although optically, the number of points is smaller than the number of subjects because the points in the graph overlap each other). A score of 5 pts or lower can be regarded as a high level of fear, and Fig. 1 shows that we recorded fearful male and fearful female students in our

sample. In the case of the girls, we recorded scores ranging from 0 pts to 20 pts (0 pts was recorded for 1 subject). When we examined the changes in fear during the swimming course, we found a statistically significant difference between the level of fear during the initial class and the final class in both genders ($p < 0.001$). This finding indicates that, in our sample, the swimming course helped to decrease the level of fear in both males and females.
A statistical analysis was also used to examine the differences in the individual tasks performed by the subjects, between the first lesson and the final lesson. In terms of the water entry indicator, we did not find a statistically significant difference in either gender ($p > 0.05$). However, we found a statistically significant difference in the "Dive in the water" task between the first class and the final class ($p < 0.01$) in either gender. This means that our subjects were significantly less fearful to dive in the water during the final class.

In the next part of our study, we examined the parental behaviour in relation to the subjects' fear of the water environment. The results from the sEMBU showed (Figure 2) that the most preferred parental behaviour reported by our subjects was overprotection; while on the contrary, the least preferred parental behaviour was rejection. The same results were obtained in terms of the parental behaviour preferred by an individual parent, i.e., the most preferred parental behaviour was overprotection and the least preferred behaviour was rejection in both fathers and mothers.

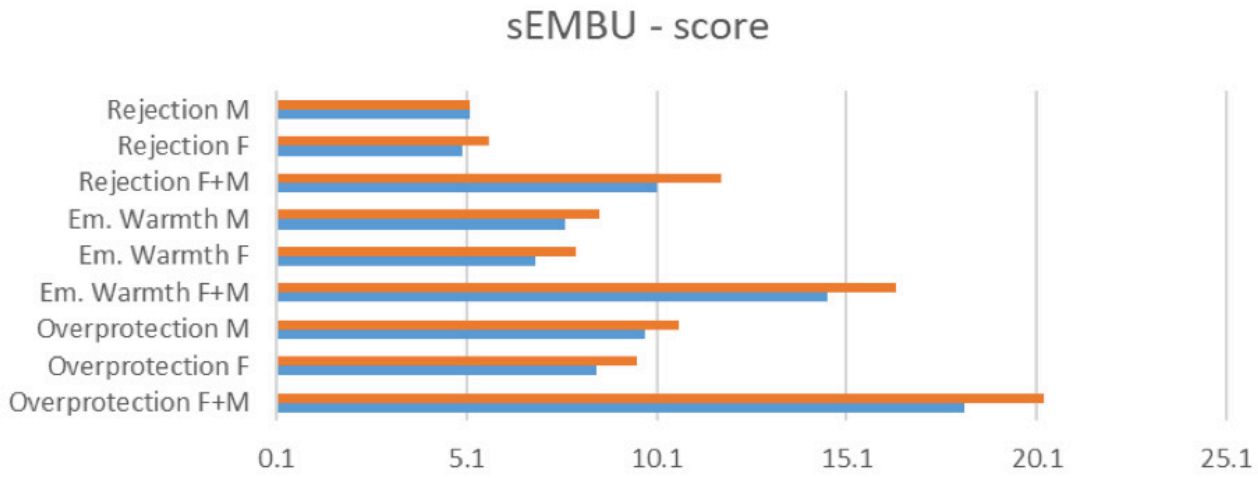

Figure 2: sEMBU score (F-father, M-mother)

The strongest correlation was recorded between the observable fear and the parental behaviour of rejection. Table 1 and 2 present the p-values and r-values of the correlations between different parental behaviours and the observable fear. Our assumption – that the strongest correlation would be detected between the parental behaviour of overprotection and a fear of the water environment – was not confirmed.

Table 1: Fear and parental behaviour (boys)

	Emotional Warmth M	Emotional Warmth F	Emotional Warmth F+M	Overprotection M	Overprotection F	Overprotection F+M	Rejection M	Rejection F	Rejection F+M
r	0.237	0.018	0.126	-0.425	-0.425	-0.468	-0.918	-0.872	-0.957
p	0.0216	0.8663	0.0882	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
n	94	94	94	94	94	94	94	94	94

Table 2: Fear and parental behaviour (girls)

	Emotional Warmth M	Emotional Warmth F	Emotional Warmth F+M	Overprotection M	Overprotection F	Overprotection F+M	Rejection M	Rejection F	Rejection F+M
r	0.212	0.152	0.191	-0.349	-0.265	-0.360	-0.913	-0.882	-0.980
p	0.0576	0.1753	0.0882	0.0014	0.0168	0.0010	<0.0001	<0.0001	<0.0001
n	81	81	81	81	81	81	81	81	81

DISCUSSION

In our sample, we found that the students' fear of the water environment changed significantly during the swimming course. Although studies by Muhamad et al. (2013) and Jánošková (2012) primarily focused on anxiety, they recorded similar findings.

Muhamad et al. (2013) found that a swimming course effectively eliminated anxiety among university students and resulted in a continued decrease. Similarly, Jánošková (2012) found that the regular participation of female university students in aqua aerobic lessons for one semester dramatically decreased the level of anxiety that the students experienced in the water environment. Both studies focussed on anxiety. However, the results of Berukoff and Hill (2010) indicated that the fear associated with swimming (i.e., perceived danger) was negatively related to both the swimming efficacy and swimming performance.

In our study, fear appeared to have a major psychological influence that negatively impacted the ability of the swimmers to perform basic swimming tasks. We found several subjects who were able to jump into the water, but they were afraid to dive into the water.

In some cases, the female subjects were ready to cry, and some of them even burst into tears when we asked them to perform the task (Dive in the water). Even though we did not force them to perform the task at all costs, their fear seemed to take over their response.

During the informal discussion with these subjects, we found that they were not able to explain exactly what they were afraid of: whether it was the depth of the pool, fear of drowning, fear of hitting the bottom of the pool, etc. Some of the subjects even admitted that this was one of their "greatest fears".

However, we found a significant difference between the first class and the final class in this regard. Therefore, we believe that even this fear may be overcome by the appropriate approach.

Stillwell (2011) suggested that because many aquatic professionals will encounter at-risk swimmers during their teaching and coaching careers, it is imperative that a humane and systematic approach to working with this particular population is created, tested and shared among the organisations, agencies and communities responsible for swimming instruction. In addition, Stillwell added that the concept of systematic desensitisation holds great promise and, when refined, could be introduced to educators in order to augment the existing methods of swimming instruction, and to eventually contribute to the elimination of preventable drownings.

In investigating the origins of the fear, we examined how parental behaviour may influence a fear of the water environment. Aboo Baka and Aboo Baka (2017) suggested that a person may take swimming lessons but never be comfortable in water because a destructive horror in relation to swimming has been cultivated by at least one of their parents. The parent may have been very insistent that no swimming or any water-related activity should be allowed so as to protect the child, and thus the fear of water is passed down to the children in a familial manner. This fear may in fact be so overpowering that it is very hard for one to forget it without a conducive programme designed specifically to overcome the phobia. We assumed that the parental behaviour of overprotection would have the strongest correlation with an observable fear of the water environment. However, in our sample, the strongest correlation was instead found between the parental behaviour of rejection and a fear of the water environment.

According to Helus (2007), the motivation towards learning (including swimming), as well as one's career orientation, completion of higher education and the overall level of success in one's life is related to the education and occupation of one's parents, as well as the cultural environment within the family and the intellectual incentives in the family. Parental behaviour therefore not only forms one's motivation but also has a long-lasting effect on one's personality and degree of life satisfaction.

A child's socialisation is most significantly influenced by parents who support the development of their child's values, habits and behaviours.

This influence remains present until adulthood. In a situation where the child is experiencing fear, parents tend to say "do not act as a baby" with the intention to support the child and encourage them to hide their fear. The influence of parents on the level of their children's fear has been the subject of many scientific studies (Bengtson, Biblarz, & Roberts, 2002; De Groof, 2008).

De Groof (2008) found that a better parent-adolescent relationship and a higher rate of parental overprotection results in a higher level of adolescents' fear.

This is caused by a higher sensitivity to dangerous situations or jeopardy by the parents who are usually more protective, and who therefore tend to protect their children against the possible danger or jeopardy more frequently (Deakin, 2006; De Groof, 2008).

Meanwhile, Boufous, Finch and Bauman (2004) found that more than 25% of parents may discourage their children from participating in physical activity or sport due to a fear that they may hurt themselves.

In addition, the findings from another study (Ross, Irwin, Irwin, Martin, Ryan, 2014) revealed that parents who had a fear of their children drowning kept their children from taking part in any formal swimming lessons.
Pharr, Irwin and Irwin (2014) investigated the parental influence on the swimming competency of children and adolescents. They found that children and adolescents whose parent or caregiver had no or a low level of swimming competence were more likely to also have no or a low level of swimming competence and to be at a greater risk of drowning.

Children and adolescents whose parent or caregiver did not encourage them to swim also reported no or a low degree of swimming competence.
Hudson and Rapee (2001) suggested that an over-controlling and protective parent could convey the message to a child that they are not able to cope with difficult situations, which may result in an increased sense of danger and anxiety.

This means that a parent who protects their child from stressful experiences, or who takes control in stressful situations, may be teaching their child that the world is a dangerous place from which they need protection and over which they have no control. The results of Muris et al. (2000) showed that parental rearing behaviours, in particular rejection and anxious rearing, were positively associated with worry.

Thus, children who perceived their parents as more rejective and anxious reported higher levels of worry. These findings are consistent with ours, since we found the strongest correlation between the parental behaviour of rejection and a fear of the water environment. Kopaničáková (2014) also suggested that rejection and a lack of emotional warmth or criticism may cause children to feel anxious.

CONCLUSION

Fear of the water environment may be the main constraint in acquiring aquatic skills for a certain group of people. As a result of this fear, the fearful individuals tend to avoid swimming courses, the water environment and activities in the water environment, which may lead to further social exclusion or feelings of embarrassment. Moreover, parents who are afraid of the water environment usually discourage their children from taking part in swimming or swimming lessons, as they are afraid of their child's safety and health. This may increase the number of non-swimmers in the next generation. We found that the level of fear significantly decreases during a swimming course, which suggests that parents should leave their fearful children in the hands of professionals. Since the results from all of the courses in our sample were combined, we recommend conducting similar research, but assessing the results of each course separately and looking at the particular programmes in order to decide which approach is the most successful.

Our assumption – that the parental behaviour of overprotection would have the strongest correlation with the subjects' fear – was not confirmed. However, the abovementioned studies suggest that an overprotective parent has a significant influence on a child's feelings of fear and anxiety. Therefore, it is important that the swimming teachers/instructors are able to talk to the parents in a fashion that will decrease the level of anxiety that the parent feels when their children enter the pool for the first time, by explaining to the parent the individual steps and the approach that is being utilised.

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STRAH OD VODE KAO FAKTOR KOJI UTIČE NA SPOSOBNOST PLIVANJA UČENIKA SREDNJE ŠKOLE

Uvod: Jedan od faktora koji značajno utiču na proces učenja plivanja je strah. Pojedinci mogu osjećati različite vrste straha uključujući strah od plivanja, strah od duboke vode i strah od utapanja, a koji u najgorim slučajevima mogu rezultirati napadima panike. Problem i cilj: Svrha ove studije je ispitati nivo straha koji učenici osjećaju kada je u pitanju voda i promjene u tom strahu tokom časova plivanja. Nadalje, htjeli smo ispitati odnos između ponašanja roditelja poput prekomjerne zaštite i straha koji učenici osjećaju prema vodi. Metode: Za prikupljanje podataka smo koristili posmatranje i upitnik. Uzorak se sastojao od 175 učenika srednje škole. Pearsonov koeficijent korelacije smo koristili za mjerenje korelacije između nivoa straha i ponašanja roditelja, a upareni t-test kako bi odredili da li se nivo straha promijenio između prvog i posljednjeg časa plivanja. Rezultati: Otkrili smo statistički značajnu razliku između nivoa straha tokom prvog i posljednjeg časa, a kod oba pola ($p < 0,001$). Najveća korelacija je zabilježena između posmatranog straha i ponašanja roditelja u vidu odbijanja. Zaključak: Otkrili smo da se nivo straha značajno smanjuje tokom časova plivanja, a što ukazuje da roditelji svoju bojažljivu djecu trebaju prepustiti rukama profesionalaca. Naša pretpostavka - da ponašanje roditelja u vidu prekomjerne zaštite ima najveću korelaciju sa strahom ispitanika - nije potvrđena.

Ključne riječi: strah, časovi plivanja, ponašanje roditelja, učenici srednje škole

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THE DEVELOPMENT OF SELECTIVE ATTENTION IN YOUNG NOVICES PARTICIPATING IN DUAL SPORTS

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ABSTRACT

Investigating the models of improving selective attention is very important, especially in sports skills within a changing environment. The purpose of the research was to investigate the effect of training selective attention through explicit and implicit processes to improve response accuracy. The participants were 60 students aged 18-20 years, randomly assigned into four groups: a) the explicit group, b) the implicit group, c) the placebo group, and d) the control group. The experimental groups participated in 12 training courses (3 times / 4 weeks) in order to improve selective attention in badminton, in laboratory simulation conditions. All the groups were evaluated in the pre-test, post-test, and retention tests. A three-way factorial ANOVA was conducted (4 Group X 2 Related-General Questions X 3 Measurement Periods) with repeated measurements on the last factor to investigate the effect of the different training methods on the accuracy of the responses with different relevant and irrelevant questions and measurement periods. The Scheffe post hoc analysis showed that on questions related to the sports content or general questions, the explicit, the implicit, and the placebo group improved their performance from the pre-test to the post-test and maintained their scores during the retention test. No difference was found between the three experimental groups, but all three were better than the control group in the post and retention test. The Scheffe post hoc analysis between groups of related and general questions showed that the scores of the experimental groups were better when responding to questions related to the sports content than when responding to general content questions during the post and retention tests. It is concluded that attention accuracy is unaffected either by a potential overload of the explicit rules or by the distraction of the dual-task setting. It is possible that in sports with a changing environment, athletes develop and interchangeably use implicit and explicit mechanisms to pay attention to and select the appropriate information from the sports setting in order to perform effectively. It seems that the perceptual abilities of individuals are based on the quality of information that they will notice from the visual stimuli of the environment.

Keywords: response accuracy, implicit learning, explicit learning, perceptual skills

INTRODUCTION

In open sports with a changing environment, the athlete's ability to adjust to the environment and the upcoming stimuli plays a crucial role in sports. Visual attention plays an important part not only in team sports in which players have to simultaneously monitor the activities and positions of multiple players but also in sports in general. The athlete is observing a display that contains a target stimulus among a variable number of distractor stimuli. The athlete must select all the sports content key points of the environment to focus their attention on and extract the necessary information from the changing sports environment. Early recognition drives on faster prediction, while efficient processing

results in better decision making and effective response to environmental stimuli (Müller & Krummenacher, 2006). Attention is described as the selection of relevant stimuli and the selective structuring of the field of perception (Memmert, 2015). Research has recognised the significance of attention in sports, and the scientific literature provides numerous findings reporting the predominant attentional capacities of experts compared to relative novices (Memmert, 2006). Based on findings in neuroscience (Van Zomeren & Brouwer, 1994), attention can be divided into four distinct sub-processes, all of which differ across individuals to varying extents: orienting attention, selective attention, divided attention, and sustained attention. In a sports context, a) orienting attention may be useful for referees since it refers to following different stimuli and extracting relevant features from the complex surroundings; b) selective attention may be useful for coaches since it gives the ability to recognise the key feature of a complex technique that needs to be changed in order for the athlete to be able to perform better on the next attempt; c) divided attention can be useful for athletes since they can divide their attention among all the relevant stimuli of a complex situation and subsequently use this information to improve their tactics; and d) sustained attention may also be useful for athletes since they maintain their attention for a longer period.

Visual attention must be differentiated from visual perception since perceptual processes, except for information acquisition, also include cognitive activities such as attention and memory, as well as motor and affective processes. Therefore, attention seems to be a sub-function of a perception whose role is to select the relevant stimuli from a large number of them in order to guide actions. Selective attention is defined as when specific stimuli are preferred over others, as opposed to simply orienting attention to single locations (Memmert, 2015). Chelazzi et al. (2013) mention that "visual selective attention is the brain function that modulates ongoing processing of retinal input in order for selected representations to gain privileged access to perceptual awareness and guide behavior" (p. 58). If efficient goal-directed behaviour is crucially mediated by visual selective attention, it is important to identify the most effective training models for improving selective attention in novices.

In a sports setting, when athletes are exposed to dozens of simultaneous stimuli, only a small part of the incoming information processes and guides behaviour because processing resources are inherently limited (Chelazzi et al., 2013). As a result, all the available stimuli compete with each other to gain access for further processing, and the visual system chooses to focus the attention on one or a few stimuli that are more relevant to the task (Chelazzi et al., 2011). Selective attention functions via a dual mechanism through which the individual focuses their attention on the most relevant information in terms of the task goal while diverting their attention from irrelevant information which may impact the execution of the aiming behaviour (Chun et al., 2011). According to the ecological theory, Abernethy, Burgess-Limerick, and Park (1994) argue that environmental information is selected through visual flow and guides the movement without the mediation of any cognitive processing. On the other hand, Müller and Krummenacher (2006) argue that the development of visual processing models discloses an interchange between the pre-attentive and attentive processes. They state that "if the output of preattentive processing is assumed to only represent basic visual features, so that the essential operations of object recognition are left to attentional processes, focal attention must be directed rapidly to the (potentially) most meaningful parts of the field, so that the objects located there can be identified with minimal delay" (p. 392), which seems to be a cognitive process. It is concluded that selective attention could be developed either by specific guidance to the most meaningful parts of the field (which presupposes cognitive processing) or without the mediation of any cognitive processing.

Therefore, an important question is which methodological approach can lead to the development of selective attention skills.

The development of selective attention is very important for sports with open skills, in a changing environment where athletes have to quickly and accurately select which stimuli to concentrate their attention on. In a review, Memmert (2015) reported that attempts to manipulate selective attention include approaches that direct the visual search to important "information-rich areas" (Magill 1998) through visual (attentional cues) or verbal (instructions) hints. This learning of sport-specific information-rich areas has been taught via a combination of video simulation and training sessions on the field, for example in badminton (Hagemann & Memmert, 2006) and volleyball (Lola & Tzetzis, 2021). The question is to discover how to provide attention-guided information to the learners through approaches such as explicit or implicit learning. Magill (1998) states that improving selective attention can be done via two training models based on the process of consciousness: a) using conscious practice models such as explicit training methods, in which the perceptual-motor problem is addressed consciously and with the contribution of working memory to create the declarative knowledge (Williams & Davids, 1995), or b) using subconscious practice models such as implicit training methods, in which the perceptual-motor problem is addressed subconsciously without the involvement of working memory to create the procedural knowledge (Couperus,

2009). Skill acquisition begins with the declarative, explicit encoding of knowledge with high cognitive processing demands, and ends with procedural, implicit encoding in which demands are low (Lola & Tzetsis, 2021). Both declarative and procedural knowledge is crucial to performance in sports which demand high-strategy skills, and the first step is for the athlete to be able to perceptually select the relevant cues from the environment while ignoring the other information. Researchers on motor learning have shown that instructions can guide attentional focus for the learning of motor skills, and support external over internal focus not only for novices but also for experts (Wulf, 2013). Muller and Krummenacher (2006) mention that the allocation of attention can be initiated either consciously or unconsciously, suggesting that guiding attention explicitly to the information-rich points may have a positive effect on the final goal of the task. Although the explicit model may be effective in improving the movement form, it has been criticised for the loss of the contextual nature of the skills in open sports. Many researchers support the beneficial effects of implicit learning on selective attention and visual skill for adults (Chun & Nakayama, 2000; Couperus 2009). Since selective attention contributes to perceptual expertise, it is important to find an effective practice model for novices.

Comparing experts and novices, several researchers have shown that experienced athletes have more efficient cognitive processing mechanisms than novices (Vestberg et al., 2017). Experienced athletes are usually able to extract and process large amounts of information faster and more efficiently from a visual presentation in their specific field of specialisation, rather than other irrelevant visual stimuli presented to them. A critical skill of sports athletes is whether they can analyse, select, and pay attention to the useful information of the sports setting and ignore the non-useful information. Many researchers have compared how experts and novices pay attention to feint or non-feint actions, concluding that experts outperform novices in inferring the true action intention of the opponent (Cañal-Bruland, 2010). The question that arises is how to improve the selective attention of novices in order for them to efficiently select and pick up the most relevant information of the sports setting. Which learning mechanism shows the greatest potential for improving the learning of selective attention?

Several researchers (Jackson & Frrow, 2005; Magill, 1998) have tested the effectiveness of subconscious versus conscious methods in laboratory tests for the development of perceptual skills, but as far as we are aware, there has been no investigation into whether these learning methods improve the selective attention skill. Most studies used high or mid-level athletes, but very few used novices. Childhood is an important and sensitive period for cognitive development; however, there is limited research on the methods of development of perceptual expertise in children (Bidzan-Bluma & Lipowska, 2018). Many training programmes have been designed and tested to improve perceptual skills in different sports, and results have shown that it is possible to acquire perceptual skills with training sessions in the field and the laboratory (Hagemann & Mememrt, 2006). If selective attention is an important perceptual skill for sports performance, it would be very interesting to identify the most effective training model for young novice athletes and lead them to the faster acquisition of perceptual expertise in sport.

AIM

The present study aimed to examine and directly compare the effect of three training models on the selective attention of young badminton novice athletes: a) an explicit training method consciously guiding the attention to the sports content key points, b) an implicit training method without the conscious guiding process, and c) a placebo group. A secondary purpose was to compare the effect of the explicit and the implicit training method on the selective attention of young badminton novice athletes to relevant or general stimuli of the sports setting.

MATERIAL AND METHODS

Participants

The sample consisted of 80 students aged 18 to 20 years (M = 18.5, SD = .6). All participants were perfectly healthy with no serious eye disorders. Participants were divided into four equal groups (N = 20). Three groups were experimental (explicit learning, implicit learning, and placebo group), and the fourth was the control group. All participants were novices, with no previous experience of racket sports.

Experimental design

All four groups performed an initial measurement (pre-test). The experimental groups then followed a laboratory intervention programme consisting of 12 courses (three times a week for four weeks). After the end of the intervention programme, a post-test was conducted followed by a retention test two weeks later. All tests were conducted in a laboratory simulating playing conditions in badminton. Independent variables were the four groups (explicit, implicit, placebo, and control group), and the three measurement periods (pre-test, post-test, and retention test).

Dependent variables were the accuracy of the responses to both relevant and irrelevant questions.

Intervention programme

The three experimental groups followed a 12-week intervention programme (3 times a week for 4 weeks) lasting 30 minutes each in the laboratory. The explicit group viewed frames of videos (lasting 5 seconds each) from badminton game scenarios with expert athletes executing a serving skill. Since a narrow focus of attention affects the development of athletes' technique (Memmert & Furley, 2007), and a wide focus of attention to the environment affects athletes' tactics (Hagemann et al., 2006), both of which are important for novice athletes, the instructors highlighted the sports content key points of both the environment and the serving skill in order to improve both technique and tactical performances. Specifically, attention was directed to: a) the kinematic characteristics of the movement (e.g., to the point of contact of the racket with the shuttlecock or to the arm and the body area), b) instructions for the concentration of attention on the key points of the environment, and c) a brief report on the difference in motor-perceptual strategies between experts and novices. The implicit group did not receive any explicit instructions, but they were instructed to watch the same videos and memorise the motor skill and the perceptual strategies/tactic scenarios of the server like a memory game. The implicit group viewed the same videos as the explicit group but also had to respond to a secondary dual cognitive task through random letter generation. The participants had to respond and simultaneously indicate the next letter of the alphabet that was presented to them (dual-task).

The placebo group watched badminton official games, and the control group participated only in the measurements.

Testing procedure

Selective attention was defined as the ability to selectively pay attention to specific important information from a variety of visual information displayed briefly with photographs of badminton game conditions (an expert executing the serving skill). In more detail, each participant was shown a life-size photo through a projector for 1.5 seconds. For each photo, the participant had to answer two questions. The first question was relevant to the badminton skills, such as whether the participant noticed specific key points of the sports skill or the environment, the direction of the shuttlecock, the depth of stroke and the execution, etc. The second question was general, such as if there was an audience watching the game, the number of referees in the picture, the current match score, the colour of the clothing of athletes and referees, etc. The questions were multiple choice with three possible answers: a) Yes, b) No, and c) I didn't notice, and the participants responded by pressing the button accordingly. As soon as the participant answered one question, the second question appeared on the screen. The participants had to answer 23 questions in total, including three practice trials before the main test, in order to understand the procedure. Superlab & Measurement Computing (Cedrus Corp.) software was used to measure the accuracy of the response and the participants responded on a specially designed RB-834 keyboard (Cedrus Corp.).

RESULTS

A three-way factorial ANOVA was conducted (4 Group X 2 Related-General Questions X 3 Measurement Periods) with repeated measurements on the last factor to investigate the effect on the accuracy of the responses of the different training methods in different relevant or irrelevant questions and measurement periods. A post-hoc Scheffe test was used to analyse significant differences ($p < .05$).

There was a statistically significant main effect ($F_{(2,77)} = 97.046$, $p < .05$) among the three measurement periods, between the relevant and irrelevant questions (questions related to the sports content / general content questions) ($F_{(1,78)} = 379.64$, $p < .05$), and among the different groups ($F_{(3,76)} = 1.51$, $p > .05$). There was a statistically significant interaction ($F_{(6, 152)} = 9.24$, $p < .05$) among the three measurement periods and the four groups, among the four groups and the different question conditions ($F_{(2,76)} = 4.63$, $p < .05$), and among the three measurements and the different question conditions ($F_{(2,77)} = 47.55$, $p < .05$). Finally, there was a statistically significant interaction among the three measurement periods, the four groups, and the different question conditions ($F_{(6,153)} = 8.44$, $p < .05$). The means and standard deviations of the groups for each case are presented in Table 1.

The Scheffe post hoc analysis showed that on questions related to the sports content or general questions, the explicit, the implicit, and the placebo group improved their performance from the pre-test to the post-test and maintained their scores during the retention test. No difference was found between the three experimental groups, but all three were better than the control group in the post and retention test. The Scheffe post hoc analysis between groups of related and general questions showed that the scores of the experimental groups were better when responding to questions related to the sports content than when responding to general content questions during the post and retention tests.

Table 1: Means and standard deviations of the groups between the testing periods, according to the two types of question.

Measurement	Question conditions	Groups	M	SD	N
Pre-test	questions related to the sports content	Control	56.75	7.30	20
		Implicit	53.75	8.56	20
		Explicit	52.50	8.35	20
		Placebo	54.25	9.63	20
	general content questions	Control	40.50	9.85	20
		Implicit	41.00	9.81	20
		Explicit	38.00	11.40	20
		Placebo	37.25	7.86	20
Post-test	questions related to the sports content	Control	57.25	7.86	20
		Implicit	67.00	9.37	20
		Explicit	71.25	6.66	20
		Placebo	69.25	7.12	20
	general content questions	Control	43.25	6.74	20
		Implicit	45.50	8.09	20
		Explicit	38.50	11.59	20
		Placebo	40.25	6.78	20
Retention test	questions related to the sports content	Control	56.75	7.30	20
		Implicit	67.75	8.95	20
		Explicit	70.75	7.82	20
		Placebo	69.00	7.18	20
	general content questions	Control	40.25	11.29	20
		Implicit	42.25	7.69	20
		Explicit	39.50	11.22	20
		Placebo	41.75	7.99	20

DISCUSSION

The present study aimed to examine the effect of different training methods of conscious (explicit) or unconscious (implicit) processing on selective attention to relevant or irrelevant stimuli in novice badminton athletes. The results of the present study showed that the participants of all three training methods (implicit, explicit, and placebo) improved over time. All three groups improved their ability to select the appropriate stimuli and focus their attention accurately, on the critical sports content key points of the environment, in contrast to the control group.

Concerning the improvement of the selective attention accuracy over time for the implicit learning group, Couperus (2009) suggests that attentional selection can be modified by implicit learning at the early stages of perceptual processing, and the present study also found that implicit learning can be an effective method for the development of selective attention in novices. Similarly, Aizenstein et al. (2004) support that selective attention accuracy can be improved via the inadvertent implicit mechanisms of brain functions. Moreover, other researchers (Chun & Nakayama, 2000) support that implicit learning of context can efficiently guide visual attention towards target information.

The explicit group also improved its selective attention accuracy over time following guidance through video-based training and specific explicit instructions towards information-rich areas (Couperus 2009; Lola et al., 2012). Jackson and Farrow (2005) mention that guidance through video and explicit instructions leads players to learn the essential link between guidance and sports performance.

Through explicit practice, the focus of attention on the sports content key points offered the participants the opportunity to recognise the appropriate stimuli, analyse them, and process them for correct responses. Castaneda and Gray (2007) showed that, although skill-focused attention tends to inhibit experts in the automated process of motor movement, a better attentional focus for novice batters allows attention to be directed to the step-by-step execution of the motor skill, which means that, for novices, explicit instructions may assist in the development of selective attention skill. However, some researchers (Memmert & Furley, 2007; Memmert & Roth, 2007) report that children who were given too many explicit instructions on important information-rich areas in team ball games showed a reduced selective attention focus and did not achieve any learning improvements in the tactical response patterns. The quantity of the instructions probably plays a critical role in the development of selective attention in sports tactics for children. It seems that the description of explicit approaches in the form of theoretical attention models is only in the starting phase (Castaneda & Gray, 2006), and more research is needed in order to build theoretical frameworks from which testable theory-driven hypotheses can be derived.

It also appeared that the placebo group improved over time. This result is probably due to the fact that participants who did not receive verbal information used different sources of information through internal feedback to a greater extent. This improvement may be due to the fact that low-complexity conditions require a small amount of attention. This result probably proves that when in a game condition, reduced attention is required, learning can take place through different sources of information. Possibly, different mechanisms of brain function were followed but presenting the same as selective attention developed inadvertently.

Also, the results showed that the participants of the placebo group ignored the irrelevant information, and perhaps the instructor's verbal instructions were unnecessary. Participants were able to identify characteristic features of the skill and extract more information about how it moves and its effect. It seems that the internal feedback that the participants had when watching professional badminton athletes was enough to develop the necessary cognitive or non-cognitive mechanisms and to improve the ability of selective attention.

Even if there are shreds of evidence that show that implicit learning is more effective than explicit learning in the acquisition of other perceptual skills such as anticipation (Tzetzis & Lola, 2015) or decision making (Lola & Tzetzis, 2021; Raab, 2003), in the present study no differences were found between the implicit and the explicit group in the improvement of selective attention accuracy, which probably means that each group improved in different ways or used both mechanisms of learning. In their review, Jackson and Farrow (2005) mention that the implicit system may act independently of the explicit system, and they both lead to performance improvement in different ways. Other researchers (Van der Stigchel et al., 2009) further explain that selective attention is governed both by automatic processes which may be developed through implicit learning and by controlled processes which may be developed through the explicit process as a result of visual stimuli.

Aizenstein et al. (2004), in a study on regional brain activation during concurrent implicit and explicit learning, remark that: "The different patterns of activation during implicit and explicit learning were not mutually exclusive, but rather overlapped, with common areas of increased activation in the basal ganglia. This common signal suggests that elements of these multiple systems can also operate in parallel" (p. 204). Moreover, Maxwell and Masters (2002) conclude that novices do not rely on one single source of focus of attention; on the contrary, they switch their attention according to the task demand, despite instructions repeatedly reminding them to pay attention to a specific focus. Müller and Krummenacher (2006) state that, although the allocation of attention is based on the (conscious) intention to search for a certain type of target, it can also be initiated by implicit processes, and they conclude that both implicit and explicit memory mechanisms are involved in the guidance of visual search. Memmert (2006) mentions that, according to the theory of early attention selection, "even if attention is concentrated in the general environment ('all-or-nothing' principle) this notion was replaced by a more flexible 'attenuator' which allows for some unattended but possibly important stimuli to 're-enter', the attentional mechanism for further processing" (p. 129). These reports show the possibly inadvertent switching between the implicit and the explicit mechanism. It is concluded that selective attention can be developed either through the explicit method (cognitive processing) or without the mediation of any cognitive processing through the implicit method, and that explicit and implicit memory mechanism may overlap, operate in parallel, or even cooperate. It seems that the development of robust theoretical models of selective attention remains a controversial issue.
The participant's ability to give accurate responses to questions concerning relevant or general stimuli was also examined, and it was found that both implicit and the explicit group were better at responding to questions related to the relevant questions for the sports content than when responding to general content questions. It seems that the visual mechanism scans the sports setting and chooses which stimuli have a link with the goal, ignoring the "noise" of the irrelevant information. There seems to be a positive effect of long-term memory on attention when exercise goals and visual stimuli are correlated (Moores et al., 2003). Chelazzi et al. (2013) mention that "objects associated with the target" tend to attract gaze more potently than unrelated stimuli and are recalled more readily in a forced-choice recency judgment procedure. Stimuli associated with the search object may have direct access to working memory and perceptual processing. Chelazzi et al. (2013) report that the human brain chooses to grant access for central processing only to the objects that have the highest priority, given the current behavioural goals, and that the knowledge accumulated over the past in similar contexts and when stimuli are task-relevant leads to faster and more accurate performance in visual search tasks.

CONCLUSION

From the results of the present study with young novices, it is concluded that explicit and implicit training methods improve selective attention accuracy. It seems that attention accuracy is unaffected either by a potential overload of the explicit rules or by the distraction of the dual-task setting. It is possible that in sports with a changing environment, athletes develop and interchangeably use implicit and explicit mechanisms to pay attention to and select the appropriate information from the sports setting and perform effectively. Moreover, simulated practice methods with a video that combine visual and auditory stimuli seem to be effective for the development of selective attention, and coaches may use their time out of the field to train via video simulated conditions to improve the selective attention of their athletes.
In the present study, attention was directed to both motor skill execution (technique) and environment (tactics), and it is unclear which underlying attentional mechanisms are better for each process;

this is a limitation of this study and also a future recommendation. Testing of implicit and explicit learning for selective attention in stress conditions is a recommendation for future studies. Finally, it is also recommended to examine the effect of different feedback programmes and guidance methods on the development of selective attention in novices and athletes in sports settings to improve the ecological validity and enable the further development of theoretical models.

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RAZVOJ SELEKTIVNE PAŽNJE KOD MLADIH POČETNIKA KOJI UČESTVUJU U SPORTOVIMA U KOJIMA SE TAKMIČE DVA IGRAČA

Istraživanje modela poboljšanja selektivne pažnje je jako važno, a posebno kod sportskih vještina u promjenjivom okruženju. Svrha ovog istraživanja je ispitati efekat treniranja selektivne pažnje kroz eksplicitne i implicitne procese za poboljšanje preciznosti odgovora. Učestvovalo je 60 studenata u dobi od 18 do 20 godina koji su nasumično podijeljeni u četiri grupe: a) eksplicitna grupa, b) implicitna grupa, c) placebo grupa i d) kontrolna grupa. Eksperimentalne grupe su učestovale u 12 treninga (3 puta / 4 sedmice) kako bi poboljšale selektivnu pažnju u badmintonu, a u uslovima laboratorijske simulacije. Sve grupe su vrednovane putem predtestiranja, posttestiranja i testova pamćenja. Trostruka faktorijalna ANOVA je provedena (4 Grupe X 2 Povezana opća pitanja X 3 Perioda mjerenja) sa ponovljenim mjerenjima za posljedni faktor kako bi se ispitao efekat različitih metoda treninga na preciznost odgovora sa različitim relevantnim i irelevantnim pitanjima i periodima mjerenja. Scheffe post hoc analiza je pokazala da su, za pitanja vezana za sadržaj sporta ili opća pitanja, eksplicitna, implicitna i placebo grupa poboljšale svoju izvedbu od predtestiranja do posttestiranja te zadržale rezultate tokom testa pamćenja. Razlike nisu pronađene između tri eksperimentalne grupe, ali su sve tri bile bolje od kontrolne grupe na posttestiranju i testu pamćenja. Scheffe post hoc analiza između grupa povezanih i općih pitanja je pokazala da su rezultati eksperimentalnih grupa bili bolji prilikom odgovaranja na pitanja vezana za sadržaj sporta nego prilikom odgovaranja na opća pitanja tokom posttestiranja i testova pamćenja. Zaključeno je da na preciznost pažnje ne utiče ni potencijalno preopterećenje eksplicitnim pravilima ni skretanje pozornosti putem postavljanja dvojnog zadatka. Moguće je da sportisti u sportovima sa promjenjivim okruženjem razvijaju i naizmjenično koriste implicitne i eksplicitne mehanizme kako bi obratili pažnju na i odabrali prikladne informacije iz sportskog okruženja za efektivnu izvedbu. Čini se da su perceptivne sposobnosti pojedinaca zasnovane na kvaliteti informacija koje će oni uočiti iz vizuelnih podražaja okoline.

Ključne riječi: preciznost odgovora, implicitno učenje, eksplicitno učenje, perceptivne vještine

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AN ANALYSIS OF THE RELATIONSHIP BETWEEN BODY STRUCTURE AND BODY DEFORMITIES IN CHILDREN AGED 11 AND 12

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ABSTRACT

The aim of this study is to determine the relationship between body structure and body deformities in students aged 11 and 12. The research was applied to 9 variables of body structure as a predictor set and 6 variables of body deformities as a criterion set. Body posture variables were estimated by the method of Napoleon Wolanski. We determined the correlation of the entire predictor set with individual criterion variables. A statistically significant association of body structure with all 6 variables of body deformities was found. The strongest realities of body structure were determined with the shoulder blades posture variable (R = 503), the abdominal posture variable (R = 492) and the scoliotic posture variable (R = 440), which indicates a very high correlation between these studied phenomena. The other 4 variables also have a significant statistical correlation with body structure ranging from medium to high correlation. The variables (fatproc) percentage of fat mass and (fatmas) total amount of fat mass had a statistically significant correlation with all the variables that measure poor posture. Based on these results, we can confirm that there is a statistically significant association of body structure with the frequency and level of poor posture and body deformities in almost all measures of body deformities.

Keywords: body structure, children, body deformities

INTRODUCTION

Posture implies a proper alignment of body segments and their balance which is achieved with the investment of minimum strength with maximum mechanical efficiency (Garrison & Read, 1980). Improper posture occurs at an early age of children and it is very important to diagnose this problem as early and as accurately as possible. Weakness or shortening of the muscles can lead to poor body posture. This can be caused by daily bad habits such as inadequate sitting and lack of motor activity that can cause poor posture or body deformities (Skender, 2001; Skender, Kendić, 2005; Kurtović, 2017; Ćolakhodzić, 2017). Today's disorders and diseases - overweight and nervous tension - are increasingly present in young people, and the free time of children and adolescents is increasingly used for activities that require almost no muscular effort (Prskalo et al., 2010). The research of Nešić, Šabić and Skender (2020)

identified a high percentage (60.3%) of those who do not recognise regular and continuous physical activity in their life habits, and as a consequence of this attitude, an inappropriate attitude towards physical exercise as a measure is noticeable in the prevention of painful lumbar syndrome. The population of students of all ages is affected by hypokinesia regardless of the place of residence, resulting from a sedentary lifestyle, which, with abundant food most often unconfirmed origins and increased intellectual and emotional activity (Nagyová & Ramacsay, 1999), is a multiplied problem. Today's population of children and young people is burdened by nervous tension, locomotor system disorders and diseases of the cardiovascular and respiratory systems. There is a growing disproportion between meeting biotic needs and the so-called civilisational needs or, more precisely, genetically conditioned and civilisationally imposed demands, and this, of course, to the detriment of the former (Findak & Prskalo, 2004).

The problem of assessing posture, selecting the best indicators and assessing the reliability of these procedures has been addressed by many scientists with the aim of detecting irregularities in the posture of children and adults (Tribastone, 1994; Palmer & Epler, 1998; Watson & Mac Donncha, 2000; Paušić, Skender, 2002,; Skender et al., 2018; McEvoy & Grimmer, 2005; Kurtović, 2017). There are several methods for analysing body composition. The most used but not accurate enough is BMI; it is expressed as the ratio of body weight in kilogrammes to the square height in metres. Significant errors are possible in people with more pronounced muscles, as well as in people with weak muscles.

One of the more accessible and popular methods is to determine the composition of the body based on different electrical resistance of tissues (Musulin, Baretić, Šimegi - Đekić, 2017; Čolakhodzić et al., 2019), and it is called bioelectrical impedance analysis (BIA). Devices that use the BIA method measure electrical signals (low safe currents of 800 μA) that pass through the components of the body - fat and muscle tissue, aqueous medium.

The subject should be in contact with metal electrodes located on the surface of the personal scale (or leaning against the body on the hands); a weak electrical signal is emitted during contact. The ability to differentiate tissues is based on the proportion of water in a particular tissue; muscle tissue contains a high concentration of water and acts as an electrical conductor, while adipose tissue has a low concentration of water and therefore acts as a resistor to the flow of electricity.

METHODS

Participants

The sample of respondents in this study is 110 female and male students aged 11 and 12, citizens of Bosnia and Herzegovina, who are clinically healthy. These are the students of the Elementary School "Gornje Prekounje" in Bihać. The main reason for choosing this population is contained in the observation of physical education and health education teachers about the frequency of spinal deformities and the sudden increase in obese children in that population.

Variables

The sample of variables for the assessment of physical deformities (Wolanski assessment)
The entire assessment procedure (Skender, 2001)

VODRGL - head posture, VORGK - chest posture, VDRLO - shoulder blades posture, VOSKO - scoliotic posture, VODRTR - front abdominal wall posture, and VOBO - leg posture.

Evaluation of posture according to the method of Napoleon Wolanski

In order to obtain some assessment of body posture or assessment of posture for one component, the following scoring is performed: 0 POINTS - if the component is within the given criteria and such condition is considered normal. 1 POINT - the first degree of impaired posture deformity is observed. 2 POINTS - second degree, i.e., marked deviation.

This system is good because it gives us the opportunity for a more detailed assessment of certain minor deviations in individual posture elements. It is also possible to evaluate the posture of the body as a whole based on the sum of negative points. Based on these indicators, we determined the prevalence of poor posture and spinal deformities. We formed two groups so that subjects who had up to 8 points were treated as the first group and we characterised them as subjects with good posture, and subjects who had 9 to 16 points were treated as the second group who had poor posture and spine deformities. 0 POINTS - excellent posture. 1-4 POINTS - very good posture, 5-8 POINTS - good posture, 9-12 POINTS - poor posture, and 13-16 POINTS - very poor posture. A sample of variables to assess body composition

BIA was measured using a TANITA body composition parameter analyser (the model of TANITA body composition analyser BF-350) in relation to the body composition and age of the subjects. This body composition assessment set includes the following nine variables: HEIGHT - body height, WEIGHT - body mass, BMI - Body Mass Index, BMR - the value of basal

metabolism, IMPEDANCE RESISTANCE - bioelectrical resistance of the body, FATPROC - percentage of fat, FATMAS - total weight of fat mass (in kg, lb) in the body, FFM - total lean body mass, TBW - the percentage of water in the body. All formulas and settings used are factory default.

Data processing methods

Data processing was conducted in the SPSS 18 software package.

Manifest variables applied in this experiment were processed by standard descriptive procedures to determine their distribution and basic function parameters, as well as the differences between the actually obtained and expected relevant cumulative frequencies.

In this way, it is possible to test the hypotheses that the distribution of the obtained results is normal, which was done - tested by the Kolmogorov–Smirnov procedure.

The following parameters were calculated for the obtained results: Arithmetic mean - Mean, Standard error - Error, Standard deviation - St. dev., Variance - Variance, Minimum value - Min, Maximum value - Max, Range, Rank, Coefficient of curvature - SKEWNESS, Elongation coefficient - KURTOSIS, and Total - Sum.

Using the factor method of the first main component, we determined the metric characteristics of three body deformity estimators according to Napoleon Wolanski. Based on the first main component, we get the so-called imaginary estimator that has the best correlations with all three of our estimators, and we processed this result in the regression analysis.

Through the regression analysis, we determined the correlation of a set of body structure variables with each body posture variable being determined separately.

RESULTS

Analysis of the central dispersion parameters of the applied variables for all subjects

Table 1 shows the central dispersion parameters of measuring instruments for all the sets of variables (variables of body posture assessment and variables of body composition) in students aged 11 and 12. The values of minimum and maximum result, arithmetic mean, standard deviation, variance, skewness, and kurtosis are presented. A good look at the table shows a good balance of descriptive statistics results. The results range within the normality of the distribution of the applied manifest variables. We can also notice this on the basis of balanced results of the median and arithmetic mean which are very close (values are close) and which tells us about the correct distribution of results and the normality of the distribution. The applied manifest variables based on the variability parameters indicate significant variability between the variables which is estimated based on the standard deviation and the variance of the applied variables. Based on kurtosis and skewness, we can assess the balance of the results which shows the mesokurtic distribution of these results. This was quite to be expected as the sample was taken from the natural population by the random sampling method, and the number of 110 subjects is quite sufficient for the normal distribution when it comes to the applied variables that we treated within the paper.

Table 1: Analysis of the central dispersion parameters of the applied variables for all subjects

	N	Range	Min	Max	Sum	Mean		Std. Dev	Varian	Skewness		Kurtosis	
							Std. Err				Std. Err		Std. Err
vodgl	110	3.00	.00	2.00	128.00	1.16	.07	.78	.61	-.18	.23	-1.10	.45
vorgk	110	2.00	.00	2.00	125.00	1.13	.05	.59	.35	-.05	.23	-.25	.45
vdrlo	110	2.00	.00	2.00	151.00	1.37	.05	.58	.34	-.31	.23	-.68	.45
vosko	110	2.00	.00	2.00	113.00	1.02	.05	.59	.35	-.00	.23	-.13	.45
vodrtr	110	2.00	.00	2.00	127.00	1.15	.05	.62	.38	-.11	.23	-.47	.45
voobno	110	2.00	.00	2.00	102.00	.92	.06	.70	.49	.10	.23	-.93	.45
Bmi	110	16.80	14.40	31.20	2175.80	19.78	.34	3.63	13.19	.94	.23	.49	.45
Fatproc	110	40.90	5.70	46.60	2352.30	21.38	.86	9.09	82.74	.57	.23	-.23	.45
Fatmas	110	37.10	2.00	39.10	1164.60	10.58	.64	6.79	46.21	1.37	.23	2.42	.45
Ffmas	110	21.60	24.40	46.00	3887.40	35.34	.48	5.06	25.68	-.00	.23	-.60	.45
Tbw	110	15.80	17.90	33.70	2848.20	25.89	.35	3.71	13.79	-.02	.23	-.61	.45
Totpor	110	315.00	466.00	781.00	63847.50	580.43	6.09	63.90	4083.30	.53	.23	.18	.45
Bmr	110	3592.00	4492.00	8084.00	640293.00	5820.84	67.63	709.33	503149.30	.60	.23	.40	.45
Vbrbod	110	16.00	.00	16.00	1017.00	9.24	.34	3.60	13.03	-.24	.23	-.33	.45
Amastj	110	56.50	27.50	84.00	5076.50	46.15	1.01	10.61	112.75	.69	.23	.64	.45
Avistj	110	43.00	132.00	175.00	16723.70	152.03	.78	8.19	67.18	.17	.23	-.24	.45

Regression analysis of body composition with an evaluation of head posture (VODLG)
Through the regression analysis, we wanted to determine the predictive value of the variables that define body composition in relation to the criterion that defines the body posture variable. According to the obtained data, we can conclude that, based on these results, it can be predicted that the set of predictors contributed to explaining the impact for the six body posture variables for which we performed regression analyses. By analysing table number 2, which shows a regression analysis with the head posture criterion, we see that the multiple correlation coefficient R = .357 and the determination coefficient .127 has a medium height. The significance of the complete predictor set to explain our model is significant at the 0.05 level. The table shows the individual contribution of each variable to the head posture criterion variable. Only two variables in the body composition space showed a high contribution in explaining the model of the criterion variable VODLG, namely FATPROC and FATMASS.

Table 2: Regression analysis of body composition and head posture, ANOVA and coefficients

Model		R	R Square	Adjusted R Square	Std. Error of Estimate	
1		.357(a)	.127	.068	.75735	
		Sum of Squares	df	Mean Square	F	Sig.
	Regression	8.549	7	1.221	2.129	.047(a)
	Residual	58.506	102	.574		
	Total	67.055	109			
		Unstandardised Coefficients	Standardised Coefficients	t	Sig.	
		B	Std. Error	Beta	B	Std. Err
	(Constant)	3.056	3.3315		.917	.361
	bmi	-.069	.109	-.318	-.657	.513
	fatproc	-.096	.035	-1.116	-2.499	.014
	fatmas	.173	.052	1.496	3.158	.002
	ffmas	-.413	.272	-2.668	-1.520	.132
	tbw	.478	.364	2.261	1.311	.193
	totpor	.000	.003	.035	.142	.888
	bmr	.000	.000	.260	1.115	.267

Dependent variable: vodgl. Predictor variables: bmr, fatproc, totpor, tbw, fatmas, bmi, and ffmas

Regression analysis of body composition with an assessment of chest posture (VODRGK)
Here we wanted to determine the predictive value of the variables that define body composition in relation to the criterion that defines the chest posture variable. By analysing table number 3, which shows the regression analysis with the chest posture criterion, we can conclude that the multiple correlation is of medium height and the coefficient of determination is .156. The complete predictor system made a statistically significant contribution to the explanation of this variable to a new significance of 0.03%. Table 3 shows the individual contribution of each predictor variable to the explanation of the chest posture criterion variable in our subjects. The variables fatmass, bmr and fatproc made the largest single contribution.

Table 3: Regression analysis of body composition and chest posture, ANOVA and coefficients

Model		R	R Square	Adjusted R Square	Std. Error of Estimate	
1		.395(a)	.156	.098	.56774	
		Sum of Squares	df	Mean Square	F	Sig.
	Regression	6.077	7	.868	2.694	.013(a)
	Residual	32.877	102	.322		
	Total	38.955	109			
		Unstandardised Coefficients	Standardised Coefficients	t	Sig.	
		B	Std. Error	Beta	B	Std. Err
	(Constant)	2.542	2.497		1.018	.311
	bmi	-.111	.078	-.675	-1.415	.160
	fatproc	-.063	.029	-.957	-2.178	.032
	fatmas	.134	.041	1.52	3.271	.001
	ffmas	-.041	.204	-.344	-.201	.841
	tbw	-.021	.273	-.130	-.077	.939
	totpor	.000	.002	-.011	-.046	.963
	bmr	.000	.000	.564	2.462	.015

Dependent variable: vodgk, Predictor variables: bmr, fatproc, totpor, tbw, fatmas, bmi, and ffmas

Regression analysis of body composition with an assessment of shoulder blades posture (VDRLO) Here we wanted to determine the predictive value of the variables that define the composition of the body in relation to the criterion that defines the shoulder blades posture variable.

By analysing table number 4, which shows the regression analysis with the shoulder blades posture criterion, we can conclude that the multiple correlation is very high (R =.) and the coefficient of determination is .253.

The complete predictor system made a statistically significant contribution to the explanation of this variable to the new significance of 0.01%.

Table 4 shows the individual contribution of each predictor variable to the explanation of the shoulder blades posture criterion variable in our subjects.

The largest individual contribution was given by the variables bmr, fatmass and fatproc. The results obtained in this table are very similar to all other results of regression analyses which means that these three variables significantly influenced and contributed to the explanation of our model of poor shoulder blades posture.

Table 4: Regression analysis of body composition and shoulder blades posture, ANOVA and coefficients

Model		R	R Square	Adjusted R Square	Std. Error of Estimate	
1		.503(a)	.253	.201	.52566	
		Sum of Squares	df	Mean Square	F	Sig.
	Regression	9.534	7	1.362	4.929	.000(a)
	Residual	28.185	102	.276		
	Total	37.718	109			
		Unstandardised Coefficients	Standardised Coefficients	t	Sig.	
		B	Std. Error	Beta	B	Std. Err
	(Constant)	.474	2.312		.205	.838
	bmi	-.055	.073	-.338	-.753	.453
	fatproc	-.082	.027	-1.275	-3.084	.003
	fatmas	.125	.038	1.441	3.286	.001
	ffmas	-.319	.189	-2.747	-1.691	.094
	tbw	.350	.253	2.207	1.382	.170
	totpor	.002	.002	.167	.721	.473
	bmr	.001	.000	.777	3.606	.000

Dependent variable: vdrlo, Predictor variables: bmr, fatproc, totpor, tbw, fatmas, bmi, and ffmas

Regression analysis of body composition with scoliotic posture (VOSKO)
With this regression analysis, we wanted to determine the predictive value of the variables that define body composition in relation to the criterion that defines the scoliotic posture variable. By analysing table 5, which shows the regression analysis with the scoliotic posture criterion, we can conclude that the multiple correlation is high and amounts to .440 with the coefficient of determination amounting to .194.

The complete predictor system made a statistically significant contribution to the explained scoliotic posture criterion variable at a new significance of 0.01%. Table 6 shows the individual contribution of each predictor variable to the explanation of the scoliotic posture criterion variable in our subjects. The largest individual contribution was made by the variables fatproc and fat mass. Fatmass has some significance, but not statistical significance in the explanation of our model.

Table 5: Regression analysis of body composition and scoliotic posture, ANOVA and coefficients

Model		R	R Square	Adjusted R Square	Std. Error of Estimate	
1		.440(a)	.194	.138	.55470	
		Sum of Squares	df	Mean Square	F	Sig.
	Regression	7.533	7	1.0768	3.498	.000(a)
	Residual	31.385	102	.308		
	Total	38.918	109			
		Unstandardised Coefficients	Standardised Coefficients	t	Sig.	
		B	Std. Error	Beta	B	Std. Err
	(Constant)	-.841	2.440		-.345	.731

bmi	.028	.077	.171	.367	.714
fatproc	-.084	.028	-1.279	-2.978	.004
fatmas	.118	.040	1.344	2.951	.004
ffmas	-.353	.199	-2.991	-1.772	.079
tbw	.451	.267	2.804	1.691	.094
totpor	.003	.002	.270	1.124	.264
bmr	.000	.000	.239	1.070	.287

Dependent variable: wax, Predictor variables: bmr, fatproc, totpor, tbw, fatmas, bmi, and ffmas

Regression analysis of body composition with an assessment of abdominal posture (VODRTR)
With this regression analysis, we wanted to determine the predictive value of the variables that define the composition of the body in relation to the criterion that defines the abdominal posture variable.

By analysing table number 6, which shows the regression analysis with the abdominal posture criterion, we can conclude that the multiple correlation is high and amounts to .492 and the coefficient of determination is .242. The complete predictor system made a statistically significant contribution to the explanation of the abdominal posture criterion variables at a significance level of 0.01%. The table shows the individual contribution of each predictor variable to the explanation of the abdominal posture criterion variable in our subjects. The largest individual contribution was given by the variable fatproc, while the variables bmi and fatmass have a certain influence, but not statistical significance in the explanation of this model of ours.

Table 6: Regression analysis of body composition and abdominal posture, ANOVA and coefficients

Model		R	R Square	Adjusted R Square	Std. Error of Estimate	
1		.492(a)	.242	.190	.56131	
		Sum of Squares	df	Mean Square	F	Sig.
	Regression	10.236	7	1.462	4.641	.000(a)
	Residual	32.137	102	.315		
	Total	42.373	109			
		Unstandardised Coefficients	Standardised Coefficients	t	Sig.	
		B	Std. Error	Beta	B	Std. Err
	(Constant)	-1.727	2.469		-.700	.486
	bmi	.139	.078	.808	1.790	.076
	fatproc	-.078	.029	-1.141	-2.739	.007
	fatmas	.069	.041	.751	1.701	.092
	ffmas	-.367	.201	-2.987	-1.825	.071
	tbw	.420	.270	2.501	1.555	.123
	totpor	.003	.002	.307	1.316	.191
	bmr	.000	.000	.285	1.312	.192

Dependent variable: vodrtr, Predictor variables: bmr, fatproc, totpor, tbw, fatmas, bmi, and ffmas

Regression analysis of body composition with an assessment of leg posture (VOOBNO)
Here we wanted to determine the predictive value of the variables that define the composition of the body in relation to the criterion that defines the leg posture variable. By analysing table number 7, which shows the regression analysis with the leg posture criterion, we can conclude that the multiple correlation is high .442 and the coefficient of determination is .178. The complete predictor system made a statistically significant contribution to the explanation of this variable to a new significance of 0.01%. The table shows the individual contribution of each predictor variable to the explanation of the leg posture criterion variable in our subjects. The variables fatproc and fatmass made the largest individual contribution.

Table 7: Regression analysis of body composition and evaluation of leg posture, ANOVA and coefficients

Model	R	R Square	Adjusted R Square	Std. Error of Estimate	
1	.422(a)	.178	.122	.65607	
	Sum of Squares	df	Mean Square	F	Sig.
Regression	9.514	7	1.359	3.158	.005(a)
Residual	43.904	102	.430		
Total	53.418	109			
	Unstandardised Coefficients	Standardised Coefficients	t	Sig.	
	B	Std. Error	Beta	B	Std. Err
(Constant)	-2.241	2.886		-.776	.439
bmi	.099	.091	.516	1.096	.276
fatproc	-.098	.033	-1.278	-2.948	.004
fatmas	.132	.047	1.278	2.779	.006
ffmas	.033	.235	.238	.140	.889
tbw	-.039	.316	-.204	-.122	.903
totpor	.005	.003	.452	1.864	.065
bmr	.000	.000	-.196	-.869	.387

Dependent variable: voobno, Predictor variables: bmr, fatproc, totpor, tbw, fatmas, bmi, and ffmas

DISCUSSION

The purpose of this study was to determine the relationships between body structure and body deformities. With this research, we found very high and significant correlations between individual variables which ranged from medium to very high statistically significant correlations. The greatest association of the body structure segment was with the measure of poor shoulder blades posture. Scapular stimulation is a measure that can indicate scoliotic poor posture as well as kyphotic posture. If the blades do not form a single flat structure with the back, then some of the stated deformities or poor postures are noticed. The greatest correlation with this variable within the individual results is given by the three variables fatproc, fatmas and bmr. The statistically most significant association was found between Fatmas and poor should blades posture. Fatmas represents the total amount of fat mass and indicates that subjects who had deformed poor blade posture had an increased amount of fat mass. It is quite understandable that obesity has a negative effect on the increase of poor posture and physical deformities, and this was to be expected. Another variable from the body structure segment is (fatproc) which measures the percentage of fat in certain body segments, which are very significant, and they also showed statistically significant realities with a measure of poor shoulder blades posture.
These two variables (fatproc) percentage of fat mass and (fatmas) total amount of fat mass were significant

in predicting almost all variables that measure poor posture. Based on these results, we can confirm that there is a statistically significant correlation between body structure with the frequency and level of poor posture and body deformities in almost all measures of body deformities, and that the greatest correlation is with the variables fatproc and fatmas.
From this research, we can draw the conclusion that, in the period of growing up, and especially at the age of 11 and 12, students need to move much more than they do. Obesity is a great enemy of children's health, especially during adolescence, and it is necessary to animate all segments of society, schools and preschools to motivate students to move as much as possible and enable them to have enough movement through physical education and extracurricular activities.

Bosnia and Herzegovina has no developed strategy to fight these global health problems, and therefore these results should serve the wider social community as a fact about the state of obesity of children in the area of Una-Sana Canton and as a recommendation for the prevention of obesity and body deformities.

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ANALIZA ODNOSA IZMEĐU TJELESNE GRAĐE I DEFORMITETA KOD DJECE U DOBI OD 11 I 12 GODINA

Cilj ove studije je utvrditi odnos između tjelesne građe i deformiteta kod učenika u dobi od 11 i 12 godina Istraživanje je primijenjeno na 9 varijabli tjelesne građe koje su činile prediktorski skup i 6 varijabli tjelesnih deformiteta koje su činile kriterijski skup. Varijable držanja tijela su procijenjene metodom Napoleona Wolanskog. Odredili smo korelaciju cijelog prediktorskog skupa sa pojedinačnim kriterijskim varijablama. Pronađena je statistički značajna povezanost tjelesne građe sa svih 6 varijabli tjelesnih deformiteta. Najjača realnost tjelesne građe je utvrđena kod varijabli držanje lopatica (R = 503), držanje prednjeg zida trbuha (R = 492) i skoliotično držanje (R = 440), što ukazuje na veoma visoku korelaciju između ovih posmatranih fenomena. Preostale 4 varijable također imaju statistički značajnu korelaciju sa tjelesnom građom i kreću se u rasponu od srednje do visoke korelacije. Varijable (fatproc) udio masne tjelesne mase i (fatmas) ukupna količina masne tjelesne mase su imale statistički značajnu korelaciju sa svim varijablama za mjerenje lošeg držanja. Na osnovu ovih rezultata možemo potvrditi postojanje statistički značajne povezanosti tjelesne građe sa učestalošću i nivoom lošeg držanja i tjelesnih deformiteta kod skoro svih mjera tjelesnih deformiteta.

Ključne riječi: tjelesna građa, djeca, tjelesni deformiteti

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CAN A DIDACTIC PROPOSAL FOR THE PHYSICAL EDUCATION CLASSROOM INSPIRED BY THE FORTNITE VIDEO GAME DEVELOP THE VALUES AND VARIOUS PSYCHOLOGICAL VARIABLES IN CHILDREN AND ADOLESCENTS?

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ABSTRACT

The effects of video games on different educational and psychological variables in children have been studied by multiple researchers. However, there are few works that address the study of pedagogical proposals for the classroom based on their mechanics and dynamics. The aim of this study was to analyse the effects of a learning experience inspired by the Fortnite video game on a sample of 586 children, studying the variables related to the social-affective sphere and psychological variables. This proposal has been developed in different Physical Education classes in various educational centres. A descriptive, cross-sectional and observational study has been carried out. The results confirm a high level of enjoyment pertaining to the students' experience, with a feeling of group cohesion, respect for peers and the rules, and increased motivation towards physical exercise. More pedagogical proposals based on video games are necessary to continue analysing the benefits they can bring in the field of formal education.

Keywords: Physical Education, Fortnite, values, video games, children, innovation

INTRODUCTION

Playing video games has become one of the most notorious leisure activities among teenagers worldwide (Entertainment Software Association, 2020). The same trend is found in Spain, where it is estimated that 47% of the Spanish population gambles regularly, with an average of 6.7 hours a week. These figures are higher in the child population, with 79% of children between 6 and 14 years of age who regularly gamble (Asociación

Española de Videojuegos, 2020).
It is a children's leisure option that motivates children due to attractive environments, continuous feedback, high interaction, progression systems, adaptive difficulty (gamification), and the possibility of continuously meeting objectives (Chóliz & Marco, 2011). The scientific community has shown its interest in studying its effects, both the positive and negative, in children and adolescents (De Sanctis, Jose Distefano, & Celina Mongelo, 2017; Lu, Kharrazi, Gharghabi, & Thompson, 2013; Primack et al., 2012; Rahmani & Boren, 2012; Salih et al., 2020; Staiano & Calvert, 2011; Staiano & Flynn, 2014; Vedechkina & Borgonovi, 2021; Villani et al., 2018) but also in the adult population (Hall, Chavarria, Maneeratana, Chaney, & Bernhardt, 2012; Xu, Liang, Baghaei, Berberich, & Yue, 2020).

Regarding its harmful potential, the focus of attention has been placed mainly on the increase in violent behaviour (de la Torre-Luque & Valero-Aguayo, 2013; Mathur & VanderWeele, 2019), his contribution to the normalisation of gambling (Griffiths, Mark D., 2018) and poor school performance (Barlett, Anderson, & Swing, 2009; Sharif & Sargent, 2006), sedentary lifestyle (Hallal, Bertoldi, Goncalves, & Victora, 2006), addictive disorders (Burleigh, Griffiths, Sumich, Wang, & Kuss, 2020; Skoric, Teo, & Neo, 2009), and other behaviour problems (Holtz & Appel, 2011; Olson et al., 2007; Salih et al., 2020) or vision problems (Mylona, Deres, Dere, Tsinopoulos, & Glynatsis, 2020).
In relation to the type of video games, shooter games are the most worrying because they have been described as increasing aggressive emotions, thoughts and behaviours, (Anderson et al., 2010; de la Torre-Luque & Valero-Aguayo, 2013) and producing a loss of awareness against aggression (Carnagey, Anderson, & Bushman, 2007).

Out of all video games, regardless of their genre or type, there is also concern about their possible addictive capacity (King, Haagsma, Delfabbro, Gradisar, & Griffiths, 2013; Le Heuzey & Mouren, 2012; Lozano-Sanchez et al., 2019; Monacis, Griffiths, Cassibba, Sinatra, & Musso, 2021). Some research has found that Massively Multiplayer Online Role-Playing Games (MMORPGs) have higher rates of problematic use than other video games (Bertran & Chamarro, 2016; Haagsma, Caplan, Peters, & Pieterse, 2013), recording an increase in addictive potential, compared to offline video games (Bertran & Chamarro, 2016; Buiza-Aguado et al., 2017; Chóliz & Marco, 2011; Starcevic, Berle, Porter, & Fenech, 2011).

In consideration of the negative effects, there are also multiple studies that confirm that video games are a viable option to promote health-related behavioural changes (Baranowski, Buday, Thompson, & Baranowski, 2008; Griffiths, M., 2004; Lu et al., 2013), benefits for the physical or psychological health of hospitalised children (Jurdi, Montaner, García-Sanjuan, Jaen, & Nacher, 2018) or improvements in the development of cognitive and motor skills such as visual perception, reaction speed, creativity, attention or executive functions (Blumberg et al., 2019; Mylona et al., 2020; Nuyens, Kuss, Lopez-Fernandez, & Griffiths, 2019; Yeh, 2015).

Along the same lines, various studies show the possibilities of using video games in counselling and psychotherapy (Fernandez-Aranda et al., 2015; Franco, 2016; Llorens, Noe, Ferri, & Alcaniz, 2015); their usefulness as an educational tool making didactic adaptations for the classroom based on the mechanics and dynamics of multiple video games (Arufe-Giráldez, 2019; Beatriz, 2017); their contribution to promoting healthy behaviours, such as socialisation (Fuster, Chamarro, Carbonell, & Vallerand, 2014), development of moral thinking and prosocial behaviours (Khoo, 2012), and even its psychotherapeutic potential (Eichenberg & Schott, 2017; Franco, 2016; Griffiths, Mark D., 2019; Primack et al., 2012; Shah, Kraemer, Won, Black, & Hasenbein, 2018).

In a society where technology plays a transcendental role in daily dynamics, and at the same time children and adolescents present high rates of sedentary behaviour (Guthold, Stevens, Riley, & Bull, 2018), the proposals for didactic experiences for the classroom inspired by different video games can be an option to promote healthy habits and educate in values.

One of the video games most played in recent years by children and young people is Fortnite. It is an online multiplayer Battle Royale genre video game created by Epic Games, and its purpose is survival on an island which all the players face simultaneously. In May 2020, there were more than 350 million users worldwide (Statista, 2021). It became popular as a violent video game without finding solid studies in the scientific literature that directly associate the violent behaviour of a child with playing Fortnite in a dosed way. A recent study (Ohno, 2021) conducted on a sample of 874 Japanese students who played Battle Royale video games, including Fortnite, demonstrated a weak link between this type of gender and aggressive feelings among modern Japanese students, noting that their results may be affected by other variables such as race, cultural differences and economic and social factors.

The aim of this study was to analyse the effects on various variables related to the social, affective and psychological sphere of a learning experience for the Physical Education classroom in 9-16-year-old children, based on the creation of a new sports game called Fortnite Physical Education (Fortnite PE) inspired by the Fortnite video game. For this, the perception of the students about the acquisition of values during the didactic

experience and the work of multiple psychological and psychosocial variables was analysed. The opinion of a sample of children and adolescents who experienced the Physical Education session based on Fortnite was analysed. A descriptive analysis was carried out, and a comparison was made by sex and between groups of children who had previous experience as video game players. Our hypothesis is based on confirming whether bringing Fortnite, one of the video games most played by children, to the classroom and creating a didactic experience inspired by it produces in students a greater enjoyment in learning various curricular contents and educates in values, meaning that while learning they develop multiple psychological and psychosocial variables.

MATERIALS AND METHODS

Participants

The minimum sample size according to the equation for finite populations, with a sample size validity for a 95 percent confidence interval, was 385 students (Cortés Cortés, Mur Villar, Iglesias León, & Cortés Iglesias, 2020; García-García, Reding-Bernal, & López-Alvarenga, 2013). Considering that the population from the 3rd year of primary education and the 4th year of secondary education in Spain was 3,018,569 students, an initial representative sample of 744 students, aged 9-16 years old, from fifteen schools in Spain was available and chosen due to convenience to obtain a representative sample that was proportional to the distribution of the school-aged population. The selection of participants in these schools was made through a consecutive non-probabilistic sampling, selecting all possible subjects who were accessed, whose PE teacher wanted to participate voluntarily, and who met the following inclusion criteria: 1) being a student from the 3rd year of primary to the 4th year of secondary education, and 2) completing the questionnaire after the experience of the Fortnite PE. The final participation was of 586 students, out of which 283 were male and 302 female (average age: 11.82 ± 1.31 years old).

Procedure

As it is a cross-sectional and observational study, the protocol established by the STROBE Declaration (Von Elm et al., 2008) has been followed, incorporating information on the 22 points proposed by this international initiative into the structure of the scientific article. Before the study began, the EDUCA Ethical Committee reviewed and authorised the protocol designed for data collection (Code 62019). The statements of the Declaration of Helsinki (21 World Medical Assembly, 1964) were followed during the entire process. In addition, the parents of students participating in the research study signed the informed consent form prior to data collection, informing them of the objectives of the study and the processing of the obtained data as well as the confidentiality of the data.
The teachers who voluntarily decided to collaborate in the data collection were provided with training that explained the purposes of the research, the protocol of the didactic experience and the protocol to be used to pass the survey to the students. In addition, all the information was published on the website of the research project, and this information was sent in writing to all participating teachers in case they had any questions. Once the teachers confirmed their understanding of the entire protocol, they went on to carry out the didactic experience with their students. On the day of putting the experience into practice, the teachers announced to the students that they would play a new sports game called Fortnite PE in Physical Education class, and after playing during the entire Physical Education class session and in different game modalities (individually and in teams), the students were given the survey so that they could share their perception of different items in the questionnaire.

Didactic experience design, Fortnite PE

The experience was based on simulating the island of Fortnite in the sports hall used for Physical Education class. A new sports game called Fortnite PE was designed, and it had a formal and functional structure of team sports but also contained certain components of individual sports through which different contents of the educational curriculum were worked out for each educational stage. The teacher previously randomly distributed numerous foam balls (simulating bullets), breastplates (simulating protection shields) and foam javelins or shuttlecocks (simulating rockets and missiles). In addition, he placed different cones that will serve to create rest huts for the players. The children start the game with their backs to the field and at the teacher's voice they all run for material to be able to throw the balls at other players and eliminate them if they hit their body. Breastplates (shields) grant players extra life. In the team mode, players who are hit by a ball, foam javelin or shuttlecock are injured in quadruped position and must wait for someone from their own team to revive them by doing 10 push-ups, 10 squats or doing 10 laps around them. . The teams can also create cabins where they can rest if they manage to get hold of 4 cones that are distributed around the sports hall. In the solo mode, players fight everyone against everyone, and if they are hit by a ball, they are eliminated by lying on the ground until the end of the game. At the end of the game, the player or team that wins and is the survivor will create the design of a dance and its choreography, and this must be danced by all the players before the start of a new game. You also get a chrome for an album consisting of 10 levels, thus reaching the first level and establishing a gamified system.Parallel to the role of player-competitors, there is another role

that the students will assume: the role of judges or referees. In each game, 4 judges are established who will ensure compliance with the rules at all times and will warn the teachers if a child cheats, assaults another child or insults him. The games last approximately 5 minutes. After finishing one game, another starts, and the solo mode alternates with the team mode and the couples mode.After the experience of a 1-hour session of Physical Education playing Fortnite PE, the questionnaire was passed to all the students, requesting the utmost sincerity in their answers and warning them that there are no better or worse answers, that they simply had to respond with what they felt or they received after having enjoyed that didactic experience. They were invited to state their doubts to the teachers in the case of not understanding a question.

Design of the questionnaire

An ad hoc questionnaire was used for data collection. The questionnaire had been previously designed and validated in a pilot study, following the indications of (Carretero-Dios & Pérez, 2007) , and its validity had been analysed by a panel of experts, obtaining a concordance index of 0.91, with agreement on all items being over 80%. In addition, a pilot study analysed the reliability of the instrument and presented the Cronbach's alpha reliability coefficients of more than 0.75, revealing that the instrument had an adequate internal consistency with composite reliability indices of more than 0.70 and mean variance extracted of more than 0.50. The scale internal consistency values were acceptable. (Campo-Arias & Oviedo, 2008)The questionnaire consisted of 3 differentiated sections that collected different types of data: 1) Items related to data on the sociodemographic variables of the children (age, sex, academic year, school, and city). 2) Items that collected data on the knowledge and use of the Fortnite video game (previous experience as a Fortnite player, average daily time and weekly frequency of play). 3) Items related to the perception and opinion about the didactic experience experienced through the adaptation of the Fortnite video game. In this last block, the respondents were asked aspects related to the social and affective-emotional sphere of the human being as well as the psychological sphere: values (respect for classmates, fair play, respect for the rules, respect for teachers, no physical violence or verbal and group cohesion), psychological and psychosocial variables (motivation towards physical exercise, self-esteem/self-confidence and social recognition) as well as aspects related to happiness and enjoyment of the experience.

Statistical analysis

The software used to perform the statistical analysis was SPSS (v.23, IBM, Endicott, NY, USA). After assessing variable normality through the Kolmogorov-Smirnov test, homogeneity through the Levene test and sphericity through the Mauchly test, a descriptive analysis was conducted for the quantitative (means and standard deviations) and qualitative variables (counts and percentages). The differences between sexes and groups based on previous experience as FORNITE players in the continuous variables were determined using unpaired t-tests. The effect size was calculated, defined as low (r = 0.10); moderate (r = 0.30), high (r = 0.50) or very high (r = 0.70) [5]. X2 analyses were used to analyse differences between groups in the categorical variables. Cramer's V was used for a post-hoc comparison of 2x2 tables, and the contingency coefficient was used for 2xn tables, obtaining the value of the statistic and the p value. The maximum expected value was 0.707; r < 0.3 indicated low association; r between 0.3 and 0.5 indicated moderate association and r > 0.5 meant high association. An error of $p \leq 0.05$ was established.

RESULTS

Table 1 contains the results of the descriptive variables and perception of experience after Fortnite PE, depending on sex. Males played a higher percentage of Fortnite than females ($\chi^2 = 114.72$; p = 0.000), while the frequency of play ($\chi^2 = 140.96$; p = 0.000) and the minutes per day they played (t = 9.87; p = 0.000) were also higher in males.

Table 1: Descriptive statistics on the previous game experience to the Fortnite video game depending on sex

		Male n = 283	Female n = 302	Differences between groups
Age (years)		11.73 ± 1.33	11.91 ± 1.28	t = -1.650; p = 0.100; 95% CI = -0.39 to 0.34
Have you ever played the Fortnite video game?	Yes	84.1%	41.1%	χ^2 = 114.72; p = 0.000
	No	15.9%	58.9%	
How many days a week do you play?	0	15.9%	57.6%	χ^2 = 140.96; p = 0.000
	1	11.0%	15.9	
	2	17.0%	9.6%	
	3	23.7%	6.6%	
	4	11.0%	4.0%	
	5	9.5%	2.6%	
	6	2.1%	1.3%	
	7	9.9%	2.3%	
How many minutes do you play per day when you play?		97.63 ± 99.82	31.97 ± 56.45	t = 9.87; p = 0.000; 95% CI = 52.60 to 78.73

Regarding their perception during the session, most of them indicated that they had felt good during the session, that the session was fun, that they found it pleasant and interesting, that they had fun doing the session, that they felt satisfied participating, that they had verified their good abilities for sport, that they learned that violence is not good, that they felt positively valued by their colleagues, that they perceived that they had contributed to the success of the team, and that, in general, they had liked the experience a lot and wanted to play more. Males showed a statistically higher percentage of agreement that the Fortnite PE session had been enjoyable and interesting for them (χ^2 = 9.66; p = 0.047), that they felt satisfied with their participation (χ^2 = 9.903; p = 0.042), that they had proved their good abilities for sport (χ^2 = 17.33; p = 0.002), and there were no differences between the sexes in the remaining items.

Table 2: Descriptive statistics on the perception of the students in relation to happiness and enjoyment of the experience after Fortnite PE experience and according to sex

Regarding your experience at the Fortnite PE session ...				
Fortnite PE taught me that exercising can be fun	SA	61.3%	61.1%	χ^2 = 6.89; p = 0.141
	A	19.9%	17.6%	
	NAD	8.2%	10.3%	
	D	3.5%	7.0%	
	SD	7.1%	4.0%	
I felt good during the Fortnite PE game	SA	53.2%	50.0%	χ^2 = 8.77; p = 0.928
	A	24.1%	25.7%	
	NAD	12.1%	14.0%	
	D	5.3%	5.0%	
	SD	5.3%	5.3%	
Fortnite PE is fun	SA	67.4%	59.0%	χ^2 = 8.141; p = 0.087
	A	17.0%	20.3%	
	NAD	6.0%	11.0%	
	D	2.5%	4.0%	
	SD	7.1%	5.7%	
I enjoy playing this Fortnite PE game	SA	62.1%	56.2%	χ^2 = 4.07; p = 0.396
	A	17.7%	19.1%	
	NAD	11.0%	16.1%	
	D	5.0%	4.0%	
	SD	4.3%	4.7%	
I am happy to participate in this Fortnite PE game	SA	49.6%	37.4%	χ^2 = 9.903; p = 0.042
	A	18.9%	25.5%	
	NAD	18.6%	23.8%	
	D	6.8%	7.6%	
	SD	6.1%	5.6%	
Overall, I liked the experience and I want to play more	SA	67.5%	62.3%	χ^2 = 2.42; p = 0.658
	A	14.1%	16.2%	
	NAD	9.5%	10.6%	
	D	3.5%	3.3%	
	SD	5.3%	7.6%	

Note: SA: Strongly agree; A: Agree; NAD: Neither agree nor disagree; D: Disagree; SD: Strongly disagree

Most participants indicated that the FORNITE PE session had helped them to have more respect for their peers, to improve their motivation towards physical exercise, to respect class rules, and to believe that exercise can be fun, with no difference between the sexes in these variables. However, the majority of participants also indicated that there were peers who had cheated in the game, although the percentage of those who indicated that there were peers who had insulted others during the game, physically assaulted others during the game, disrespected the teacher or excluded or marginalised peers was quite low, with no sex differences in these items.

Table 3: Descriptive statistics on the perception of the students in relation to the work of values after Fortnite PE experience and according to sex

Regarding your experience at the Fortnite PE session ...				
Fortnite PE helped me respect my colleagues	SA	29.0%	25.2%	χ^2 = 4.22; p = 0.377
	A	28.3%	26.5%	
	NAD	21.2%	28.1%	
	D	11.0%	11.3%	
	SD	10.6%	8.9%	
Fortnite PE helped me to respect the class rules	SA	31.8%	27.2%	χ^2 = 5.29; p = 0.259
	A	27.1%	23.8%	
	NAD	21.1%	28.5%	
	D	8.2%	9.6%	
	SD	11.8%	10.9%	
Fortnite PE taught me that violence is not good	SA	39.7%	42.9%	χ^2 = 3.40; p = 0.492
	A	21.3%	20.9%	
	NAD	17.7%	15.0%	
	D	7.1%	10.0%	
	SD	14.2%	11.3%	
I have contributed to the success of my team	SA	51.2%	43.9%	χ^2 = 3.89; p = 0.420
	A	26.1%	29.6%	
	NAD	13.8%	17.6%	
	D	5.3%	6.0%	
	SD	3.5%	3.0%	
There are colleagues who cheated in the game	SA	45.6%	47.7%	χ^2 = 4.58; p = 0.332
	A	10.6%	13.9%	
	NAD	15.5%	16.9%	
	D	9.2%	7.9%	
	SD	19.1%	13.6%	
Some colleagues have insulted others in the Fortnite PE game	SA	21.9%	20.2%	χ^2 = 5.47; p = 0.242
	A	13.4%	14.9%	
	NAD	16.3%	20.9%	
	D	10.6%	13.6%	
	SD	37.8%	30.5%	
There are teammates who have physically attacked	SA	7.8%	9.3%	χ^2 = 3.15; p = 0.532
	A	7.1%	8.6%	
	NAD	13.4%	11.3%	
	D	12.4%	15.9%	
	SD	59.4%	55.0%	

others in the Fortnite PE game				
I have disrespected the teacher	SA	2.5%	2.3%	$\chi^2 = 2.80$; p = 0.592
	A	3.2%	2.3%	
	NAD	4.9%	3.3%	
	D	7.4%	5.3%	
	SD	82.0%	86.8%	
I have excluded or marginalised a colleague	SA	4.6%	3.6%	$\chi^2 = 3.26$; p = 0.515
	A	2.8%	1.7%	
	NAD	6.0%	3.6%	
	D	5.7%	6.0%	
	SD	80.9%	85.1%	

Table 4: Descriptive statistics on the perception of the students in relation to psychological and psychosocial variables after Fortnite PE experience and according to sex

Regarding your experience at the Fortnite PE session ...				
Fortnite PE improved my motivation towards physical exercise	SA	48.1%	38.5%	$\chi^2 = 6.45$; p = 0.168
	A	24.0%	30.6%	
	NAD	14.8%	17.9%	
	D	4.9%	5.6%	
	SD	8.1%	7.3%	
I find Fortnite PE pleasant and interesting	SA	51.6%	42.1%	$\chi^2 = 9.66$; p = 0.047
	A	27.6%	26.2%	
	NAD	11.3%	16.9%	
	D	5.7	8.3%	
	SD	3.9%	6.6%	
I am happy to participate in this Fortnite PE game	SA	49.6%	37.4%	$\chi^2 = 9.903$; p = 0.042
	A	18.9%	25.5%	
	NAD	18.6%	23.8%	
	D	6.8%	7.6%	
	SD	6.1%	5.6%	
I have proven my good abilities for sport	SA	44.5%	28.8%	$\chi^2 = 17.33$; p = 0.002
	A	26.9%	29.8%	
	NAD	18.4%	27.2%	
	D	4.2%	6.6%	
	SD	6.0%	7.6%	
My colleagues have assessed me positively	SA	37.7%	28.6%	$\chi^2 = 6.20$; p = 0.184
	A	26.0%	30.9%	
	NAD	21.7%	25.6%	
	D	7.8%	9.0%	
	SD	6.8%	6.0%	

Note: SA: Strongly agree; A: Agree; NAD: Neither agree nor disagree; D: Disagree; SD: Strongly disagree

Table 5: Descriptive statistics and opinions after FORNITE PE depending on previous experience playing the FORNITE videogame

		Previous experience n = 363	No previous experience n = 223	Differences between groups
Regarding your experience at the Fortnite PE session				
Fortnite PE taught me that exercising can be fun	SA	62.3%	59.6%	$\chi^2 = 5.62$; p = 0.229
	A	19.4%	17.5%	
	NAD	8.3%	10.8%	
	D	3.9%	7.6%	
	SD	6.1%	4.5%	
I felt good during the Fortnite PE game	SA	53.6%	48.4%	$\chi^2 = 4.98$; p = 0.289
	A	25.7%	23.5%	
	NAD	11.3%	15.8%	
	D	4.1%	6.8%	
	SD	5.2%	5.4%	
Fortnite PE is fun	SA	66.8%	57.2%	$\chi^2 = 7.01$; p = 0.135
	A	18.0%	19.8%	
	NAD	7.5%	10.4%	
	D	2.8%	4.1%	
	SD	5.0%	8.6%	
Fortnite PE taught me that violence is not good	SA	41.4%	41.4%	$\chi^2 = 2.68$; p = 0.612
	A	20.7%	21.6%	
	NAD	18.0%	13.5%	
	D	7.7%	9.9%	
	SD	12.2%	13.5%	
Overall, I liked the experience and I want to play more	SA	67.5%	60.5%	$\chi^2 = 6.11$; p = 0.190
	A	15.7%	14.3%	
	NAD	8.5%	12.6%	
	D	3.0%	4.0%	
	SD	5.2%	8.5%	

DISCUSSION

No research has been found in the scientific literature that addresses the educational potential of a Fortnite-based classroom learning experience. One of the aspects that has most concerned researchers is the amount of time children spend playing video games.

Some authors Ponce-Blandon et al., 2020) confirm that more than 21 hours per week can involve a greater number of negative consequences. In our work, an average daily playing time spent on Fortnite in the amount of 97 minutes in boys and 31 minutes in girls is verified, not confirming a high playing time.

Some studies (Hoffman, Paek, Zhou, & Turkay, 2020) have confirmed that the use of video games in education can improve students' motivation to learn content from different subjects. Although in this study, the direct effects of the Fortnite video game have not been analysed, instead presenting a didactic adaptation for the Physical Education classroom inspired by the said video game, most of the students who have had this didactic experience affirm that it has increased their motivation towards the practice of physical exercise, registering only 13% of boys and girls who disagree with this statement.

Incorporating the methodology regarding the use of video games or their didactic adaptations by the teacher in the classroom can encourage the fulfilment of multiple educational purposes, such as a culture of educational success, coexistence, inclusion or diversity (Marín-Diaz, Sampedro-Requena, & Mac Fadden, 2019), or even promote active citizens or address problems or addictions being highly perceived by students. The students' perception of working on values such as respect or non-violence during the Fortnite PE experience has been high, both in students with previous experience in the video game and in those without experience.

The good perception of contribution to the success of the team also stands out, that is, a strong group cohesion and feeling of being key in the group, reaching values close to 80%.

This is another of the positive aspects of the didactic adaptation because in the real video game, each player is at home isolated kilometres from other players; however, in the didactic adaptation, everyone shares space and this contributes to a greater perception of belonging to the team by children and adolescents and their role and responsibility in the outcome of the game.
In relation to prosocial behaviours, a study (Shoshani & Baruch, 2021) conducted on a sample of 845 children between 9 and 12 years of age that analysed the social paradox of Fortnite showed that players who played as a team had more helpful behaviours than the individual player.

The social context and psychological experience influenced the prosocial behaviour of the participants more than the formal content of the game. In our work, although aspects related to the family environment were not collected, the didactic experience provoked a positive perception of teamwork and helped it, confirming that multiple prosocial behaviours can be worked on.

In a meta-analysis review (Anderson et al., 2010) on violent video games and their possible effects on the aggressiveness, empathy and prosocial behaviours of the players, it is highlighted that more experimental research is necessary with large samples of players and longitudinal ones with long time intervals to analyse the aggressive behaviour that these video games can provoke. Additionally, we highlight several findings from intervention studies that suggest that specific programmes that involve schoolchildren and families can reduce exposure to violent media and the frequency of unjustified aggressive behaviour. In our study, the presented didactic adaptation confirms a low perception of violent behaviours by schoolchildren, stimulating positive values and teamwork in addition to other psychological variables. More than half of the students participating in this research expressed their great respect for other classmates, and a figure of close to 100% expressed their respect for the teacher.
Other works have analysed the importance of training parents to prevent negative effects of video games and enhance their possible positive effects (Cordelet & Soulie, 2020; Hughes & Brooks, 2020), understanding that playing video games like Fortnite does not always generate addiction in minors (Carter, Moore, Mavoa, Gaspard, & Horst, 2020).

In relation to the emotional response, online multiplayer video games such as Fortnite offer very powerful emotional experiences, with children and adolescents experiencing multiple emotional experiences that include a certain degree of tension, feelings of frustration, anxiety, fear, excitement, and joy. A study (Nash, Lee, Janson, Richardson-Olivier, & Shah, 2020) analysed the syncope suffered by a 9-year-old boy during the Fortnite game, stating that after being eliminated by another player when he was about to win the game, the boy became angry and lost consciousness, and the previous existence of an unknown ventricular arrhythmia was found, which aggravates during play. It is an isolated case with previous pathologies, but what is confirmed by various studies (Cox, 2019; Ivarsson, Anderson, Akerstedt, & Lindblad, 2011; Valladao, Middleton, & Andre, 2020; Wang, Song, Gao, & Tao, 2020) is the significant increase in heart rate and blood pressure among young children who play video games; however, the magnitude of this is less than that observed during standard physical exercise. In our work, the students have predominantly had a positive perception, regardless of whether during the game they experience common emotions in the practice of a competitive sport such as a certain degree of tension, fear of failing or doing it wrong, anger or frustration.

About 8 out of 10 boys and girls said they enjoyed the experience, felt good during the game, and saw it as a lot of fun. No data related to heart rate were recorded, but teachers reported high levels of intensity of physical exercise with some fatigue of the players due to the high demand of motor skills and physical condition. Perhaps in the Fortnite PE didactic experience, the increase in the heart rate of the traditional sport is added to the increase in the heart rate recorded in e-sports or online multiplayer video games in the Battle Royale mode.

Fortnite has proven to be a success in the field of video games and some authors (Carter, Moore, Mavoa, Horst, & Gaspard, 2020; Song, 2020) have tried to analyse the causes of their success, attributing them to multiple factors. This didactic adaptation inspired by Fortnite has also been a success among schoolchildren, especially those who had previous experience with the video game, and who stated that they would like to continue playing Fortnite PE in more Physical Education classes by 83.2%, compared to 74.8% who had no prior experience. Other researchers (Dietrich et al., 2021) have carried out didactic experiences based on Fortnite, other video games and famous television series (pop culture) to work on different curricular contents in university students. In a questionnaire also based on a Likert scale where different variables were measured, in the item I enjoyed the use of pop culture in my studies, 57.6% of the students indicated that they were in complete agreement and 35.2% that they were in agreement. Similar figures have been obtained in our work where 66.8% of the children completely agreed that Fortnite PE was fun and 18% agreed. This goes to show that bringing the type of leisure that children consume to the classroom to explain and work on different contents established by the educational curriculum increases the enjoyment of the students.

CONCLUSION

The aim of this study was to analyse the effects of a learning experience inspired by the Fortnite video game on the perception of students about the acquisition of values during it and the work of multiple psychological and psychosocial variables such as motivation towards sports practice. It is found that the Fortnite PE learning experience enhances the work of multiple values and psychological and psychosocial variables in the Physical Education classroom among schoolchildren.

Through a didactic adaptation of a video game popularly labelled as negative for the education of minors, multiple curricular contents can be worked on and promote the education of children in their social, affective-emotional and psychic sphere. More didactic experiences are necessary, addressing the work of curricular content in school based on innovative proposals inspired by the world of video games, thus establishing a link between children's leisure and their obligations as students and promoting correct behaviour during play.

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DA LI DIDAKTIČKI PRIJEDLOG ZA NASTAVU FIZIČKOG OBRAZOVANJA POTAKNUT VIDEO IGROM FORTNITE MOŽE RAZVITI VRIJEDNOSTI I RAZLIČITE PSIHOLOŠKE VARIJABLE KOD DJECE I ADOLESCENATA?

Mnogi istraživači su proučavali efekte video igara na različite obrazovne i psihološke varijable kod djece. Međutim, postoji malo radova koji se bave proučavanjem pedagoških prijedloga za nastavu zasnovanih na njihovom mehanizmu i dinamici. Cilj ove studije je analizirati efekte obrazovnog iskustva potaknutog video igrom Fortnite na uzorku od 586 djece proučavanjem varijabli vezanih za socijalno-afektivnu sferu i psihološke varijable. Ovaj prijedlog je razvijen na različitim časovima fizičkog obrazovanja u raznim obrazovnim centrima. Provedena je deskriptivna, transverzalna i opservacijska studija. Rezultati potvrđuju visok nivo zadovoljstva iskustvom studenata uz osjećaj grupne povezanosti, poštivanja vršnjaka i pravila, kao i povećanu motivaciju ka tjelovježbi. Potrebno je više pedagoških prijedloga zasnovanih na video igrama kako bi se nastavila analiza koristi koje one mogu donijeti na polju formalnog obrazovanja.

Ključne riječi: fizičko obrazovanje, Fortnite, vrijednosti, video igre, djeca, inovacija

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THE USAGE DISPLAY OF A NEW TRAINING TECHNOLOGY IN BUILDING ENERGY PROFILES AMONG PROFESSIONAL SOCCER PLAYERS

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ABSTRACT

The goal of this study is to present the way for solving the problem of creating winning energy profiles among professional soccer players by using a new training technology in planning, programming and implementing the soccer teams' training. The hypothesis is that the desired goal can be achieved by utilising mathematical control, thereby reducing the volume of and increasing the intensity of training sessions. The research was conducted on a sample of 25 professional soccer players. The trainings that were the subject of the analysis were performed by running in aerobic, anaerobic alactate and anaerobic lactic regimes. The exact performance time without breaks for physical preparation trainings was 40 minutes. The intensity was individually programmed according to the upper limit of the participant's capacity, with a calculated decrease in volume which affected the aimed adaptations of the body. The subjects in this study were programmed to consume an average of 96.9 litres of VO2 and 484.5 kcal per 1 aerobic workout. In 1 anaerobic lactate training, they consume 228 litres of VO2, 1,288g of muscle glycogen and 920 kcal of energy for useful work, and make 184 litres of VO2debt and 1,288 grams of lactic acid. In anaerobic alactate training (ATP + CP), they consume an average of 218 litres of VO2 and 1090 kcal. The effectiveness of the proposed solutions is analysed, and a foundation for both innovating training practice and future research on this topic is established.

Keywords: soccer, glycogen, lactic acid, energy, energy profile

INTRODUCTION

In order to create soccer players and teams with winning mentalities (Milosevic, Amanovic, Milosevic, 2020), a variety of characteristics must be developed, among which energy profiles are considered to be among the most important (Lozovina, Lozovina, Bonacin, 2011; Milošević, Dopsaj, Blagojević, 1999; Milošević, Milić, 2010; Milošević, 2010; Milošević, Milošević, 2010; Milošević, Milošević, Yourkesh, 2012; Milosevic, Jourkesh, Milosevic, 2020a; Milosevic, Amanovic, Milosevic, 2020b; Milosevic, Milosevic, 2020; Mourtziapis, Alexopoulos, Kaprinis, Dedes, Panoutsopoulos, Kipreos, 2020; Mura, 2010; Nédélec, McCall, Carling, Legall, Berthoin, Dupont, 2012; Izet, Alić, Bajramović, Jelešković, Ćović, Likić, Mekić,

2016). The functional analyses of elite soccer matches indicate that teams made up of players whose energy profiles allow for the consumption of 1,600 kcal per match while simultaneously producing 46% energy in anaerobic lactic, 14% in anaerobic alactate, and 40% in aerobic regimes of production, can be expected to achieve significant results (Bangsbo, Mohr, Krustrup, 2006; Carpinelli, 2008; Hoff, 2005; Milošević, 2010; Milošević, Milošević, 2010; Milošević et al., 2012; 2020a,b; Milosevic, Milosevic, 2020; Reilly, 2007; Williams, 2012). The training must create a configuration of energy adapting characteristics of players which will allow them to create 736 kcal of anaerobic energy created by burning muscle glycogen, with a speed of creation of 115 kcal/min to 145 kcal/min in order to run at speeds ranging from 23/4 km/h to 24.84 km/h and to repeat such runs 125 times during matches (Bangsbo et al., 2006; Carpinelli, 2008; Hoff, 2005; MacLaren, Morton, 2012; Milošević et al., 2012; Milošević, Nemec, Nemec, Milošević, 2017; Milošević et al., 2012; 2020a,b; Milosevic, Milosevic, 2020; Osgnach, Poser, Bernardini, Rinaldo, Prampero, 2010; Reilly, 2007; Volkov, Nesen, Osipenko, Korsun, 2000; Williams, 2012). They must then create 224 kcal of alactate energy, which is obtained by burning ATP and CP, with a speed of creation of 490 to 610 kcal/min, which would allow them to run at speeds of 28 km/h to 34 km/h (Bangsbo et al., 2006; Carpinelli, 2008; Hoff, 2005; MacLaren, Morton, 2012; Milošević et al., 2012; Mura, 2010; Nédélec et al., 2012; Osgnach et al., 2010; Reilly, 2007). Finally, they must be enabled to create 640 kcal of aerobic energy by burning fat and carbohydrates in their blood, at a speed of creation from 16.5 kcal/min to 25 kcal/min, which would allow them to run at speeds ranging from 24 km/h to 19 km/h and achieve swift recovery, regardless of their discipline (Bangsbo et al., 2006; Carpinelli, 2008; Hoff, 2005; MacLaren, Morton, 2012; Milošević et al., 2012; Milošević, 2010; Milošević et al., 2012; Osgnach et al., 2010; Reilly, 2007; Volkov et al., 2000; Williams, 2012). This means that, per match, they can consume 140 litres of oxygen in aerobic work and 1120 grams of glycogen during leg extension in order to create 160 litres of oxygen debt and 1120 grams of lactic acid (Bangsbo et al., 2006; Carpinelli, 2008; Hoff, 2005; MacLaren, Morton, 2012; Milošević et al., 2012; Milošević, 2010; Milošević et al., 2012; Osgnach et al., 2010; Reilly, 2007; Volkov et al., 2000; Williams, 2012). The functional analysis of elite matches has demonstrated that 46% of energy is created anaerobically from muscle glycogen (leg extensor muscles), 14% of energy is created anaerobically from ATP and CP sources, and 40% is created aerobically by burning fat and carbohydrates from the blood (Bangsbo et al., 2006; Carpinelli, 2008; Hoff, 2005; MacLaren, Morton, 2012; Milošević et al., 2012; Milošević, Milić, 2010; Milošević, 2010; Milošević, Milošević, 2010; Milošević et al., 2012; Osgnach et al., 2010; Reilly, 2007; Volkov et al., 2000; Williams, 2012). This analysis of elite soccer matches brings up the question of the validity of today's training technology in the creation of professional soccer players' energy profiles (Malacko, Rađo, 2004; Milošević, 2010). That is why innovation of current training technology, with the mathematical control of the transformational process which would result in shortening the time period of the training process alongside the maximisation of training results, is proposed (Boone, 2014; Jakovlev, 1979; Malacko, Rađo, 2004; Milošević et al., 1999; Milošević, Milić, 2010; Milošević, 2010; Milošević, Milošević, 2010; Milošević et al., 2012; Milosevic, 2020a; Milosevic et al., 2020b; Milosevic, Milosevic, 2020; Volkov et al., 2000).

PROBLEM AND AIM

New training technology, which to a great extent relies on hardware-software support (VAC Bioengineering) for data acquisition and analysis, selection, programming of the game and training performance as well as recovery and performance during sports competitions, allows for the precise planning, programming and follow-up of the realisation of the set training goals (Milošević et al., 1999; Milošević, Milić, 2010; Milošević, 2010; Milošević, Milošević, 2010; Milošević et al., 2012; Milosevic, 2020a; Milosevic et al., 2020b; Milosevic, Milosevic, 2020). This approach has yielded good results in the physical preparation of athletes as well as members of special units of the military and the police (Milošević et al., 1999; Milošević, Milić, 2010; Milošević, 2010; Milošević, Milošević, 2010; Milošević et al., 2012; Milosevic, 2020a; Milosevic et al., 2020b; Milosevic, Milosevic, 2020). The main goal of this paper is to present a way for solving the problem of creating winning energy profiles among professional soccer players by using a new training technology in planning, programming and implementing the soccer teams' training. Furthermore, the aim of this paper is to analyse the effectiveness of the proposed solutions and establish a foundation for both innovating training practice and future research on this topic.

METHODS

Participants

The creation of the energy profile was carried out on a sample of 25 professional soccer players playing for First League teams. Their average age was 24 ± 5.3 years, average height 173 ± 4.5 cm, average weight 74.86 ± 5.9 kg, and Body Mass Index 22.5 ± 2.1. The participants provided their informed consent, while the study procedures were approved by the university's ethics committee.

Table 1: Programming Training Effects From One Aerobic Training

Effects/Days	Monday	Tuesday	Wednesday	Friday	Saturday
Energy source	Glycogen	Fats	Glycogen	Fats	Glycogen
Oxygen consumption (l)	96.9	76.5	98.94	71.4	100.98
Energy consumption (kcal)	484.5	382.5	494.7	357.0	504.9
Aerobic power (kcal/min)	24.2	19.1	24.7	17.8	25.2
Exceedance of the anaerobic threshold	Yes	No	Yes	No	Yes
The amount of force generated from 1 training (daN)	276.5	218.3	282.3	203.7	288.2

Note: An example of hardware and software system functioning (VAC Bioengineering)

Design

The experiment was carried out during a season period without matches. Three daily training sessions were scheduled. The first was dedicated to the creation of aerobic energy potential of the soccer players (Table 4). The time of continuous work in the training sessions was 20 minutes. The second session was dedicated to the creation of anaerobic lactic energy potentials (Table 6). The training consisted of 4 sets of 4 repetitions (Milošević, 2010).

The speed at which the distance was run each minute over the course of repetitions in the sets was determined for each individual with the help of equations (7). The number of sets and the number of repetitions was determined according to the energy power of each individual (equations 1, 3-14). The time of work per training without breaks was 16 minutes. The breaks in the sets between the first and second repetition lasted 3 minutes, those between the second and third repetition lasted 2.5 minutes, and the ones between the third and fourth lasted 2 minutes (equations 9 – 11).

The pauses between the repetitions lasted the amount of time needed so that, from repetition to repetition, the distances, the oxygen debt and the amount of lactic acid increased in a controlled manner (equations 3 -7) (Milošević, 2010). Throughout the pause in the sets, the participant was unable to resynthesise the expended glycogen (Milošević, 2010). The pauses between the sets lasted 8 minutes, allowing enough time to resynthesise the expended glycogen from the leg muscles (equations 9 – 11).

The third training session was dedicated to the creation of anaerobic alactate energy potentials (Table 5). The time of work without pause on the ATP component per training came out to 63 seconds (equation 2), while the pauses between repetitions in the sets came out to 20 seconds, with 3 minutes between the sets (equations 9 – 11) (Milošević, 2010; Milošević, Milošević, 2010). During the 3-minute breaks, the football elements were done lightly.

The time and distance run in the ATP regime was determined for each individual with the help of equations (2). The unmitigated time of work without pause for the CP component came out to 144 seconds (equation 2), while the pauses between the repetitions in the sets came out to 30 seconds, with 3 minutes between the sets (equations 9 – 11) (Milošević, 2010; Milošević, Milošević, 2010). During the 3-minute breaks, the football elements were done lightly. The time and distance run in the CP regime were determined for each individual with the help of equations (2). The total unmitigated time of all three training sessions came out to around 40 minutes (Milošević et al., 1999; Milošević, Milić, 2010; Milošević, 2010; Milošević, Milošević, 2010; Milošević et al., 2012; Milosevic, 2020a; Milosevic et al., 2020b; Milosevic, Milosevic, 2020).

Within this context, assigning daily or multi-day training load, the work regime or direction is scheduled in accordance with the regenerative capacities and length of time dedicated to rest (equations 9, 10 and 11), which allows each soccer player to recover (Boone, 2014; Milošević, Milošević, 2014; Nédélec, 2012).

The intensity is closely programmed for each individual according to his upper limits of capacity (equations 1-14). Each training programme was designed in 7 steps: diagnostics, identification of energy status (equations 1-9, 12-14), states, capacities, and rules of development for each soccer player, comparing the current state and capacity with the demands of matches and the results sought to be achieved, calculation and quantification of goals (Table 1, 2 and 3), daily programming aerobic, anaerobic lactate and alactate training (Table 4, 5 and 6), calculating weekly training effects and changes (Table 8, 9 and 10), and finally generating reports (Milošević et al., 1999; Milošević, Milić, 2010; Milošević, 2010; Milošević, Milošević, 2010; Milošević et al., 2012; Milosevic, 2020a; Milosevic et al., 2020b; Milosevic, Milosevic, 2020).

Table 2: Programming Training Effects of 1 ATP and 1 CP of Anaerobic-Alactate Training of Effective Duration (ATP - 1.03 minute; CP- 2.4 minutes)

Values	M	SD
ATP distance run (m)	600	30
Energy consumption - ATP training (kcal/min)	480	38.4
CP distance run in (m)	1,320	52.8
Energy consumption - CP training (kcal/min)	610	54.9
Force generation - ATP training (daN)	599	41.93
Force generation - CP training (daN)	866	86.6

Note: ATP-adenosine triphosphate, CP – creatine phosphate. An example of hardware and software system functioning (VAC Bioengineering). M - Mean, SD - Standard deviations

Table 3: Programming Training Effects in 1 Lactic Training

Values	M	SD
Distance run (m)	5,124	307.44
Oxygen debt (l)	224	22.52
Generated lactic acid (g)	1,288	128.1
Glycogen consumption (g)	1,288	128.1
Energy consumption (kcal)	1,830	190.8
Force generation (daN)	5,443.2	272.16
Anaerobic lactate power (kcal/min)	100	3.9

Note: An example of hardware and software system functioning (VAC Bioengineering). M - Mean, SD - Standard deviations

Experimental Procedures

The following describes the procedures based on which the training effects and changes were individually measured, programmed and controlled.

The directly measured variables are: body weight, time elapsed for 20m, 50m and 100m running from a standing start, 20m from a flying start, the distance covered when running 1 minute and 12 minutes, anaerobic threshold, and the rate and amount of oxygen consumed at the anaerobic threshold using standardised procedures and equipment.

Maximum oxygen uptake is calculated according to the following equation: $VO_{2max} = [(3.134304 \cdot 10^{-7} \cdot K^2 + 0.02077344 K - 9.03125) \cdot BW] \cdot 1000^{-1}$ (1)
where VO2max – is the maximum oxygen uptake expressed in litres per minute (L. min-1), K – the value of the Cooper 12-minute running test expressed in metres (m), and BW – body weight expressed in kilograms (kg).

If we display the obtained results in a coordinated system of a participant at a 20m height and a flying start, 50m and 100m high start, during running for 1 minute and in a Cooper test, in which we exact the time reached on an abscess and the distance covered and between the points using the method of the smallest roots pertaining to the lines of shapes:
y = ax + b (2)
then the coefficient of the lines will represent the speed at which oxygen is maximally consumed (VO_2max), while the section of the ordinate, coefficient b, will represent the distance which the participant covers using adenosine triphosphate (ATF). When the value of the Cooper test is removed from the equation, the coefficient will represent the distance which the participant covers using creatine phosphate (CP).
Estimating the maximal amount of oxygen debt (the capacity of the oxygen debt) in the work of each individual athlete is carried out according to the following function:

$$VO_{2debt} = (a_1 \cdot e^{k1 \cdot v} + a_2 \cdot e^{k2 \cdot v}) - VO_{2max} \quad (3)$$

where VO_2debt – the maximal amount of oxygen debt is expressed in litres (L), VO_2max – the maximal amount of oxygen consumed is expressed in litres per minute (L . min-1), v – speed is expressed in ms-1, e – the base of the natural logarithm, as is k - the constant, which depends on the athlete's weight and the degree with which he masters moves, as well as:
$VO_2debt = [(k/60) / vVO_2max]3. VO_2max$ (4)
where VO2debt – maximal amount of oxygen debt expressed in litres (L), k/60 – speed of running distance in 1 minute expressed in metres per second, vVO2max – the speed at which the maximal amount of oxygen is consumed expressed in metres per second (ms-1), VO2max – the maximal consumed oxygen expressed in litres per minute (L . min-1).
Estimating the maximal amount of lactic acid created in the study of each individual athlete is carried out according to the following function:

$$LA = [(a_1 \cdot e^{k1 \cdot v} + a_2 \cdot e^{k2 \cdot v}) - VO_{2max}] \cdot 7 \quad (5)$$

where LA – is the amount of lactic acid expressed in grams (g), VO_2max – is the maximal oxygen spent expressed in litres per minute (L . min-1), v – is the speed expressed in ms-1, e – is the base of the natural logarithm, while k is the constant which depends on the weight of the athlete and the degree to which he masters his moves.
Estimating a one-time oxygen debt:

$$VO_{2\ debtjk} = (0.94\ v_{1\ min} / vVO_{2max})^3 \cdot VO_{2max} \quad (6)$$

where $VO_{2\ debtjk}$ – is the one-time oxygen debt expressed in litres per minute L . min-1), % v_1 min – 94% is the speed of running on a track during one minute expressed in metres per second (ms-1), VO_2max – is the maximum oxygen

uptake expressed in litres per minute (L . min-1). Estimating the speed on the distance in which the one-time oxygen debt is being created: V_{jd} = 0.94 . (k/60) (7) where vjd – is the speed of the one-time distance expressed in metres per second (ms-1), k/60 – is the speed of the running of the distance of 1 minute expressed in metres per second (ms-1).

For one litre of VO2 debt, about 7 grams of lactic acid are created, that is, 7 grams of glycogen are spent because the work is realised with almost maximum intensity.
Estimating the level of glycogen over the production of lactic acid in running is done using the following formula:
Y = 0.92 . X + 6.7 (8)
where: Y – is the amount of glycogen dimensionally expressed in grams (g), while X – is the level of lactic acid dimensionally expressed in grams (g).

Consuming one litre of oxygen is the equivalent of releasing the energy of 5 kilocalories.
The speed of compensating the oxygen debt is calculated using the method of kinetic analysis, using the following two-component exponential equation:
$VO_2 = V^1O_2 . eK_1t + V^2O_2 . eK_2t$ (9)
where VO_2 – is the level of oxygen spent minus the value of rest in each moment upon finishing the task, V_1O_2 and V_2O_2 – is the level of alactate and lactic consumption of O2 in the starting moments of recovery, e – the base of the natural logarithm, t – is the time of recovery, K_1 and K_2 – are the constants of alactic and lactic consumption of O_2 in the recovery period.
The alactate and lactic fraction of the O_2 debt is calculated by dividing their starting level with the corresponding constants.

Estimating the speed of compensating the oxygen debt in the first and second three minutes after maximal lactic work is done using the following function:

O_2 = - 0.28 . t + 1.45 (10)
where O_2 – is the compensated oxygen debt expressed in litres (L), t – the time of recovery expressed in seconds (s).
The following three minutes of recovery for the compensated oxygen debt are calculated according to the following function:
O_2 = - 0.06 . t + 0.61 (11)
where O_2 – is the compensated oxygen debt expressed in litres (L), t – is the time needed for recovery expressed in seconds (s).
Estimating the dynamic of the accrual of glycogen deposited in the muscle under the influence of training is carried out according to the following function:

$PG = a . e^{k.t}$ (12)
where PG – is the amount of glycogen growth under the influence of the training session expressed in grams (g), e – the base of the natural logarithm, while k – is the constant of the lactic consumption of oxygen in a particular training session, t – the length of time of one or more training sessions.

Estimating the training distance of running in one minute is carried out according to the following function:

TD = 0.95 (a_0 + a_1 – MD) (13)
where TD – the training distance expressed in metres (m), MD – the maximal distance run in one minute expressed in metres (m), a0 i a1 – the constants which depend on the critical speed and maximal tolerance of oxygen debt among athletes.

The force in running is calculated according to the following function:

$F = 2 m d G / t^2$ (14)

where F – is the force expressed in decanewtons (N), m – body mass, G - (body weight multiplied by 9.81), a – is the acceleration during running expressed in metres per second squared (m/t^2).

Exercise Protocol

Each soccer player was diagnosed and had their training effects, energy reserves, energy capacities, energy strength, and other variables calculated (Table 7). Given that the training is individually programmed, we will demonstrate how to create training programmes using only the average results of one participant.

Once the amount of oxygen which will be consumed during one month is determined, then the amount of oxygen is distributed for individual training session during the week (Table 4). The aerobic training is designed so that, during each week for the duration of one month, in the first week, we reach one peak (95% VO2max), in the second, we reach two peaks (96% VO2max), in the third, we reach three peaks (98% VO2max), and in the fourth, we reach one peak again (100% VO2max). Oxygen uptake on the other days ranges from 70% to 100% VO2max. The percentage of oxygen consumption is programmed using the percentage of speed at which oxygen is maximally consumed (vVO2max). Each aerobic training session lasted for a period of 20 minutes. When the oxygen uptake for each day of the week is determined, the running speed is also determined for each training session (Table 4). The speed should enable oxygen uptake, which is prescribed for a particular day of training. Multiplying the speed by 20 minutes gives us the distance covered for each training session, and by

multiplying the oxygen uptake by five, we also get the energy consumption (Table 4).

Table 4: The Weekly Aerobic Training Work Programme

Work/Days	Monday	Tuesday	Wednesday	Friday	Saturday
Running speed (ms^{-1})	4.4	3.5	4.5	3.2	4.6
The time of running (min)	20	20	20	20	20
Distance (m)	5,280	4,200	5,400	3,840	5,520

Note: An example of hardware and software system functioning (VAC Bioengineering)

When the ATP distance and time which is run have been determined (equation 2), then the distance which must be run in one ATP training, the distance and time in which the CP distance is run (equation 2), followed by the CP distance which must be run in one training session, the amount of energy consumed in one ATP and CP training session, and the amount of force created in one ATP and CP training session (equations 1, 3, and 14), the number of sets in ATP and CP training session, the number of repetitions in ATP and CP training, and the length of pause in ATP and CP training session (equations 9-11), with the ATP and CP training session which contributes to the creation of energy profiles are designed based on these numbers (Table 5):

Table 5: Weekly ATP and CP Anaerobic-Alactate Training Work Programme

Work/Days	Monday	Friday
The number of sets in 1 ATP training	5	
The number of repetitions in 1 ATP set	6	
Running speed of 1 ATP repetition in a set (ms^{-1})	8.8	
The time of 1 ATP repetition (s)	2.2	
The length run in 1 ATP repetition (m)	20	
The length of break between repetitions (s)	20	
The length of break between ATP sets (min)	3	
The number of sets in 1 CP training		4
The number of repetitions in 1 CP set		5
Running speed of 1 CP repetition in a set (ms^{-1})		7.1
The time of 1 CP repetition (s)		7.2
The length run in 1 CP repetition (m)		51
The length of break between repetitions (s)		30
The length of break between CP sets (min)		3

Note: An example of hardware and software system functioning (VAC Bioengineering)

Table 6: Weekly Anaerobic Lactic Training Work Programme

Work/Days	Wednesday	Saturday
The number of sets in 1 training	4	4
The number of repetitions in 1 set	4	4
Running speed of 1 repetition in a set (ms^{-1})	6.1	6.1
The time of 1 repetition (s)	60	60
The length run in 1 repetition (m)	366	366
The length of break between repetitions (min)	3:2.5:2	3:2.5:2
The length of the break between sets (min)	8	8

Note: An example of hardware and software system functioning (VAC Bioengineering)

Anaerobic lactic training contributing to the creation of energy profiles for soccer players (Table 6) is programmed when the following are determined: the number of sets and the number of repetitions, the distance and time of running for one repetition, the pause between repetitions in the sets and between the sets themselves, the amount of energy and glycogen which is consumed in one repetition in the sets, and the amount of lactic acid and force created in one repetition of running in a set (equations 1, 3 - 7, 9 – 11, 14).

RESULTS

The results of the aerobic, anaerobic lactic, and anaerobic alactate status of soccer players, as well as their aerobic, anaerobic alactate, and anaerobic lactic training effects, can be seen in tables 7, 8, 9, and 10.

Table 7: The Aerobic, Anaerobic Lactic, and Anaerobic Alactate Energy Status of Professional Soccer Players

Variables	M	SD
VO2 max ($l\ min^{-1}$)	3.90	0.47
Running speed for VO2 max (ms^{-1})	4.66	0.26
Aerobic strength ($kcal\ min^{-1}$)	18.5	2.0
Consumption of VO2 upon exceeding the anaerobic threshold ($ml.\ kg^{-1}.\ min^{-1}$)	48.6	5.9
Running speed (ms^{-1})	3.7	0.4
Lactate system strength		
Max. speed (ms^{-1})	6.5	0.13
Max. distance ($m.\ min^{-1}$)	390	8.4
Working distance ($m.\ min^{-1}$)	366	10.0
Working distance when running (ms^{-1})	6.1	0.16
Max. oxygen debt (l/min)	18	1.62
Working distance oxygen debt ($l\ min^{-1}$)	14	1.33
Working distance lactic acid ($g\ min^{-1}$)	98	6.6
Working distance glycogen consumption ($g\ min^{-1}$)	98	6.7

Working distance energy consumption (kcal min^{-1})	70	6.1
Distance covered by running in intermittent regime (m)	5,124	404
Oxygen debt in intermittent regime (l)	186	28
Glycogen consumption in intermittent regime (g)	1,288	166
Energy consumption in intermittent regime (kcal)	1,080	190
Strength of alactate system (enabled by the degradation of creatine phosphate, CP)		
Running speed (ms^{-1})	7.1	0.7
Distance covered (m)	51	3.6
Duration of running (s)	7.2	0.16
Strength of alactate system (ATP)		
Max speed 20 m flying start ms^{-1})	8.8	0.56
Speed in standing start at 20 m (ms^{-1})	8.3	0.56
Running speed (ms^{-1})	3.7	0.02
Force necessary for establishing movement (N)	680	3.32
Ability to accelerate (m/t^2)	5.0	0.46

Note: An example of hardware and software system functioning (VAC Bioengineering). M - Mean, SD - Standard deviations

Table 8: Weekly Records of Training Effects and Changes

Values, Aerobic Effects and Changes	Week 1 results
Distance run (km)	24,240
Effective time of training (min)	100
Weekly number of training	5
Number of overlapped anaerobic thresholds	3
Oxygen consumption (l)	444.72
Max. oxygen consumption (l)	3.8
Energy consumption (kcal)	2,223.6
Average aerobic power (kcal min^{-1})	22.2
Amount of generated force (daN)	1,269

Note: An example of hardware and software system functioning (VAC Bioengineering).

Table 9: A record of Training Effects and Changes in Week 1

Values, Alactic Effects and Changes	Week 1 Results
ATP distance run (m)	1,200
Effective time of ATP training (s)	132
Duration of breaks (min)	46
CP distance run (m)	2,045
Effective time of CP training (s)	288
Duration of breaks (min)	34
Weekly number of training	2
ATP energy consumption (kcal)	960
Anaerobic ATP power (kcal min^{-1})	457
CP energy consumption (kcal)	1,220
Anaerobic CP power (kcal min^{-1})	305
Heart blood flow - ATP (l)	58.6
Heart blood flow - CP (l)	81.6
Force generation - ATP training (daN)	1,198
Force generation - CP training (daN)	1,732

Note: An example of hardware and software system functioning (VAC Bioengineering).

DISCUSSION

As shown in the results section, on average, for one week throughout all three training sessions (Table 8, 9, 10), a soccer player expends 5,513 kcal, 1,102.4 litres VO2, and 2,576 grams of glycogen for needed work, while simultaneously creating 368 litres VO2debt and 2,576 grams of lactic acid. The maximal aerobic strength was 24.2 kcal/min, while the lactic one was 100 kcal/min, and ATP was 480 kcal/min, with CP amounting to 610 kcal/min. The monthly energy effects of all three training sessions are achieved when the weekly energy effects of all three training sessions are multiplied by 4.

Table 10: A record of Training Effects and Changes in Week 1

Values, Lactic Effects and Changes	Week 1 Results
Distance run (km)	10,248
Effective time of training (min)	32
Duration of breaks (min)	108
Weekly number of training	2
Energy consumption (kcal)	1,840
Oxygen debt (l)	368
Glycogen consumption (g)	2,576
Generated lactic acid (g)	2,576
Blood flow (l)	704
Force generation (daN)	10,886.4

Note: An example of hardware and software system functioning (VAC Bioengineering).

On average, per match, when applying various systems of the game at European and World championships and the League of Champions, soccer players expend 1,500 kcal (Milošević, Milić, 2010; Milošević, 2010; Milošević, Milošević, 2010, 2014; Milošević et al., 2012, 2017; Nédélec, 2012; Osgnach, 2010; Reilly, 2007; Volkov et al., 2000). Out of that, they expend 795 kcal of aerobic created energy and 705 kcal of anaerobic created energy

(Milošević, Milić, 2010; Milošević, 2010; Milošević, Milošević, 2010, 2014; Milošević et al., 2012, 2017; Nédélec, 2012; Osgnach, 2010; Reilly, 2007; Volkov et al., 2000). The speed of the production of lactic energy (lactic power) was 135 kcal/min, followed by ATP regime energy 600 kcal/min, CP regime 400 kcal/min, and aerobic regime 17.7 kcal/min (Milošević, Milić, 2010; Milošević, 2010; Milošević, Milošević, 2010, 2014; Milošević et al., 2012, 2017; Nédélec, 2012; Osgnach, 2010; Reilly, 2007; Volkov et al., 2000). If we compare the amount of created energy in lactic training with the amount of energy created in European and World championships and League of Championships, it is evident that the lactic training sessions expend far more (Table 3) (920 kcal compared with 705 kcal) energy created anaerobically from muscle glycogen. Moreover, aerobic training sessions expend aerobically created 484.5 kcal/min by burning fat and carbohydrates in the blood, 480 kcal from ATP sources and 610 kcal/min from CP sources (Table 1, 2, 3). In the lactic training sessions, they expend 228 litres VO2 (Table 3). In the aerobic work, they expend another 96.9 litres VO2, in ATP work, 96 litres VO2 and in CP work, they expend 122 litres VO2 (Table 1, 2). At the European and world matches, an average of 200 litres VO2 is expended, out of which 70 litres is in aerobic work (Milošević, Milić, 2010; Milošević, 2010; Milošević, Milošević, 2010, 2014; Milošević et al., 2012, 2017; Nédélec, 2012; Osgnach, 2010; Reilly, 2007; Volkov et al., 2000). The average oxygen debt created by soccer players during European and world matches is 160 litres (Milošević, Milić, 2010; Milošević, 2010; Milošević, Milošević, 2010, 2014, 2020; Milošević et al., 2012, 2017; Mourtziapis et al., 2020; Mura, 2010; Nédélec et al., 2012; Osgnach et al., 2010; Reilly, 2007). In aerobic lactic training sessions, soccer players (Table 3) create on average 184 litres VO2debt, followed by 1,288 grams of lactic acid, and expend 1,288 grams of glycogen, run 5124 m, as opposed to elite soccer players who, over the course of a match, create 160 litres of oxygen debt and 1,120g of lactic acid and expend 1,120g of glycogen to run 4830 m in lactic mode (Milošević et al., 2012).

The influence of the application of new training technologies is such that the results on all amounts describing the energy profiles of soccer players continually increase (Table 8, 9, 10). These increases influence the formation of a stable energy profile capable of producing, expending, and resynthesising more energy than at the most demanding European and world matches (Milošević, Milić, 2010; Milošević, 2010; Milošević, Milošević, 2010, 2014, 2020; Milošević et al., 2012, 2017; Nédélec et al., 2012; Osgnach et al., 2010; Reilly, 2007; Volkov et al., 2000; Williams, 2012). In anaerobic working conditions in one anaerobic lactic training session created according to the new training technology, a soccer player with average results expends 131% more energy than at said international matches, and in all work regimes he or she expends 183% more. Collectively, all three training sessions expend 183% more energy than is expended at international matches, which is evident from the increase in the quality and speed of energy processes. In one anaerobic lactic training session, a soccer player with average results creates 115% more oxygen debt and lactic acid than is created at international matches. This means he expends and resynthesises for that percent more glycogen in leg extensions during the time of training. The energy profile of just the lactic training is created according to the new technology and covers the energy profile of football matches from 131% - 183%. Each player working according to the new training technology is capable of creating and expending 131 - 183 percent more fuel, that is, creating a greater number of runs in the intermittent regime, at a greater speed throughout the match, compared to the demands of the most intense international matches (Milošević, 2010). As the lactic training sessions progress, this percentage rises at a speed which is characteristic and already known (software-calculated dynamics of progress to the realisation of full capacity for each football player) (Milošević, 2010; Milošević, Milošević, 2010, 2014, 2020; Milošević et al., 2012, 2017). It can be calculated for any moment in time for each player throughout one training session, a month, half a year, a year, and so on.

During the 4 weeks of lactate training, we can expect an increase at an average rate of: 5.4% or 4.6 grams of glycogen reserves in leg extensors (equation 12), 15% in the maximal and relative consumption of oxygen (equation 1), 14% in the increase of the lactic threshold, 14% in the consumed and created energy, and 15% in the rate of recovery as a consequence of adapting the body to intensive work (equations 9 - 11) (Boone, 2014; Jakovlev, 1979; Milošević, Milić, 2010; Milošević, 2010; Milošević, Milošević, 2010, 2014, 2020; Milošević et al., 2012, 2017; Nédélec et al., 2012; Osgnach et al., 2010; Reilly, 2007; Volkov et al., 2000). What is simultaneously known is how achieving the level of muscle glycogen enables the soccer player to increase the distance run at the same time (6% for 4 weeks of lactate training on average), but also how fast he is and how much more he can endure, compared to players training according to already familiar training templates (Milošević, 2010; Milošević, Milošević, 2010, 2014, 2020; Milošević et al., 2012, 2017). What is furthermore known is how soccer players become more capable to renew their spent fuel, that is, to recuperate (equations 9 - 11). Using this style of training, all mechanisms of recuperation are perfected (Boone, 2014; Jakovlev, 1979; Milošević, 2010; Volkov et al., 2000). It is known how many times they can repeat high intensity running over the course of one match without tiring – 125 times on average (equations 10, 13). What is also known is how they can carry out acceleration and sprints, and at what speeds, jumps, and with how many fast and positioning attacks (Boone, 2014; Jakovlev, 1979; Milošević, 2010; Volkov et al., 2000). This explains the capacity of soccer players who trained and were led according to the new training technology and are able to effortlessly play two back-to-back matches without breaks at a faster rate with

much faster attacks, or who easily play two matches per week (Wednesdays and Saturdays) over the course of several months (Milošević, 2010; Milošević, Milošević, 2010, 2014; Milošević et al., 2012; Milosevic, 2020a; Milosevic et al., 2020b; Milosevic, Milosevic, 2020).

CONCLUSION

According to all of the analyses we conducted, it can be concluded that the aim of this study has been confirmed. By using the new training technologies (Milošević et al., 1999; Milošević, 2010; Milošević, Milošević, 2010, 2014; Milošević et al., 2012; Milosevic, 2020a; Milosevic et al., 2020b; Milosevic, Milosevic, 2020) coaches are able, with absolute control, very precisely, in determined time intervals and through various training sessions, to create winning energy profiles among their soccer players as a result of adapting the player's body to intensive work (Boone, 2014; Jakovlev, 1979; Osgnach et al., 2010). These profiles can support all the tactical ideas coaches might have in all systems of the game. They can create a special configuration which satisfies the demands of the competition in which, over a longer period of time, two high-intensity matches are played per week. Finally, the conclusion is that the training sessions achieved greater training energy effects over those achieved by soccer players at the European and world matches. Applying the new training technology and the proffered model of training work provides total control of the energy effects of training and the process of building energy profiles of professional soccer players.

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PRIKAZ UPOTREBE NOVE TRENAŽNE TEHNOLOGIJE ZA IZGRADNJU ENERGETSKIH PROFILA PROFESIONALNIH FUDBALERA

Cilj ove studije je predstaviti način rješavanja problema kreiranja pobjedničkih energetskih profila profesionalnih fudbalera koristeći novu trenažnu tehnologiju u planiranju, programiranju i realizaciji treninga fudbalskih timova. Hipoteza je da se željeni cilj može postići korištenjem matematičke kontrole, čime se smanjuje obim i povećava intenzitet treninga. Istraživanje je provedeno na uzorku od 25 profesionalnih fudbalera. Treninzi koji su predmet analize su provedeni trčanjem u aerobnom, anaerobnom alaktatnom i anaerobnom laktatnom režimu. Tačno vrijeme izvođenja bez pauza za treninge fizičke pripreme je trajalo 40 minuta. Intenzitet je bio individualno programiran u skladu sa gornjom granicom kapaciteta učesnika uz izračunato smanjenje obima koje je uticalo na ciljane adaptacije tijela. Ispitanici u ovoj studiji su programirani da troše prosječno 96,9 litara VO2 i 484,5 kcal po 1 aerobnoj vježbi. Na jednom anaerobnom laktatnom treningu oni troše 228 litara VO2, 1,288g mišićnog glikogena i 920 kcal energije za produktivan rad, a kreiraju 184 litra VO2duga i 1,288 grama mliječne kiseline. Na anaerobnom alaktatnom treningu (ATP + CP) oni troše prosječno 218 litara VO2 i 1090 kcal. Analizirana je efektivnost predloženih rješenja uz uspostavljanje osnove za inovativnu trenažnu praksu i buduća istraživanja na ovu temu.

Ključne riječi: fudbal, glikogen, mliječna kiselina, energija, energetski profil

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DYNAMICS OF DIFFERENT EXPRESSIONS OF UNIVERSITY SPORT IN A BRAZILIAN UNIVERSITY

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ABSTRACT

Brazilian university sport is currently organised and managed by legal organisations, but also by autonomous ones. This study aimed to analyse the participation of undergraduate students at the State University of Maringá (UEM) in two different manifestations of university sports. We used basic descriptive statistics for data analysis. As a result, we highlight the greater possibility for students to participate in their own events (23.41%), compared to official competitions (2.45%). We concluded that competitions organised autonomously are able to include a larger number of students, when compared to official ones. However, they have limitations, such as the lack of representativeness of some courses through students' organisations.

Keywords: sport, universities, competitions

INTRODUCTION

Sports practice, through its plural character, takes place through various possibilities, and can be developed in multiple contexts, including universities (Malagutti, Starepravo, 2020a).

Such practice is not a recent phenomenon, and its first manifestations are historically referenced to English universities in the 19th century (Hargreaves, 1986; Elias & Dunning, 1992; Guttman, 1994; White, 2004; Cooper, 2004).

Since then, there have been significant changes in their own competition systems and organisational models, which highlights the globalisation process of sports practice among university students in various parts of the world (Lewis, 1970; Smith, 1990; Toledo, 2006; Hawkings, Baker, & Brackebusch, 2015; Brunton & Mackintosh, 2017; Coakley, 2017; Weight, Jensen, & Osborne, 2020).
In the Brazilian context, the development of university sports has had different periods with moments of government dependency, but also periods of autonomous organisation (Toledo, 2006; Borges, & Buonicore, 2007; Starepravo et al., 2010; Starepravo, 2011; Pessoa & Dias, 2019; 2020).

The Brazilian Confederation of University Sports (in Portuguese "CBDU") is the highest entity of Brazilian university sport. It organises the main competitions held during the academic calendar, and its main role, in addition to the organisation of championships, is enabling representation in international competitions.

In the national scenario, there are also regional federations responsible for local university sport competitions (Starepravo et al., 2010; Starepravo, 2011).

Yet, currently, there are also parallel sporting events, organised by students' associations that are not directly linked to national university sport. Instead, they are usually state or regional events involving courses from some Universities (Malagutti & Starepravo, 2020; Malagutti et al., 2020a).

In this perspective, regarding the reality of the State University of Maringá (in Portuguese UEM), there are two different active entities for organisation and participation in university sports. The Sports and Recreation Coordination (CDR) is connected to the university and is responsible for coordinating and offering the academic community sports and recreational activities. In addition, it organises and manages the participation of UEM in official university sports competitions in the state, such as the University Games of Paraná, a competition held by the University Sports Federation of Paraná (in Portuguese "FPDU") (Malagutti, 2012; Malagutti et al., 2020b).

At the State University of Maringá, there are Academic Athletic Associations (AAAs), entities that represent academics from various courses who organise their own sports competitions, without the involvement of official organisations (Malagutti, 2020b). It is important to note that the organisations mentioned so far have their own particularities and objectives in terms of achievements, such as the Inter-Athletic Associations Games of Maringá.

PROBLEM AND AIM

Based on the scenario of university sport at UEM, this article aims to make a comparison between two sports competitions organised according to the management models presented, analysing the impact regarding the participation of students/athletes in competitions, taking into account the maximum possible number of participants in each competition. For the analysis, we chose the University Games of Paraná (in Portuguese "JUPs"), promoted by FPDU, and the Inter-Athletic Associations Games of Maringá (in Portuguese "JOIA"), organised by UEM academics.

METHODS

This research is explanatory, as it seeks to identify factors that determine or contribute to the occurrence of phenomena (Gil, 2019; Gratton & Jones, 2010). According to Gratton and Jones (2010), explanatory research is the one that goes deeper into knowledge on reality, analysing the reasons why things happen. In order to carry out the research, specific documents about the current situation of students enrolled in undergraduate courses at UEM were collected and subsequently analysed, as well as the General Regulations for the sports competitions analysed.

Procedures

Data collection was divided into two stages. In the first one, the General Regulations of the following competitions were analysed: 1) University Games of Paraná - 2020, and 2) Inter Athletic Associations Games - 2019. In this first stage, the models of each competition were identified according to their specificities, as well as the sports present in each competition and the maximum number of students/athletes registered for each competition. In the second stage, using the official documents provided by UEM, based on data from the competitions highlighted in this study, the maximum participation of students enrolled in UEM undergraduate courses was estimated.

Reviews

For the analysis of the results, the data were catalogued using the Microsoft Excel® software. The results were expressed by simple descriptive statistics, through absolute values, and by calculating the percentage in relation to the maximum number of participants in each sports competition analysed.

RESULTS AND DISCUSSION

The State University of Maringá is a public university maintained by the state of Paraná and its State Department of Science, Technology and Higher Education. Its administrative offices are located in the main campus, in the city of Maringá - Paraná, as well as most of its undergraduate and graduate courses. The university is also present in several towns with other campuses and advanced bases (State University of Maringá, 2020).

It currently has more than seventeen thousand students enrolled in its sixty-nine undergraduate courses spread across its campuses. Taking into account only the students and undergraduate courses of the main campus, the institution has 12,489 students enrolled in 42 undergraduate courses (State University of Maringá, 2020).

Regarding the university sports competitions mentioned in this study, we will now present a brief introduction on the games and their goals, in addition to conducting an analysis of the figures provided by UEM on the students enrolled in the undergraduate courses of the main campus.

The first competition we analysed is the University Games of Paraná (JUPs), which had their 59th edition in 2019.

The competition is held annually in host cities in the state of Paraná, with the participation of public and private universities. According to its General Regulations, the event aims to promote sports among university students in the state, as well as socio-sports integration among students/athletes (University Sports Federation of Paraná, 2019).

In addition to the aforementioned goals, the University Games of Paraná are the only state competition to qualify students/athletes and Universities to the Brazilian University Games (in Portuguese "JUBs"), organised by the Brazilian Confederation of University Sports (CBDU). The students/athletes who qualify to the national competition are invited by the Federation and submitted to its regulations (University Sports Federation of Paraná, 2020).In the aforementioned competition, there are fourteen sports, which can be divided into the following categories: Sports, Academic-Scientific competitions, E-Sports and Paralympic sports (see Table 1). Paragraph 8 of Art. 36 of the General Regulations of the competition emphasises the participation of a student/athlete in only one sport (University Sports Federation of Paraná, 2020).

Table 1: Sports offered by the University Games of Paraná and participation of undergraduate students from the State University of Maringá.

MODALITIES	Maximum number of athletes per University	
	Male	Female
Academic*	1	1
Athletics	30	30
Athletics (Paralympic)*	6	6
Basketball	12	12
FIFA*	1	1
League of Legends*	5	
Futsal	12	12
Handball	14	14
Judo	14	14
Karate*	6	6
Swimming	30	30
Swimming (Paralympic)*	6	6
Volleyball	12	12
Beach Volleyball	6	6
TOTAL BY GENDER	155	155
TOTAL	**305**	

SOURCE: University Sports Federation of Paraná, 2019a, 2019b.
*Sports that are offered only by the University Games of Paraná

After presenting the sports of the last edition of the University Games of Paraná, it is important to highlight the possibility of a student to participate in non-traditional sports. In this sense, we highlight the Academic-Scientific category, which consists of academic work presentations. Besides, the event encompasses E-Sports and Paralympic sports, as previously mentioned.

By analysing the figures on the sports offered by the University Games of Paraná in relation to the number of students enrolled in the undergraduate courses offered by UEM (12.489 students), and considering the maximum number of athletes that can register for the competition (305), we can find a coverage result and maximum participation of approximately 2.45% of students/athletes from the aforementioned institution (see Figure 1).

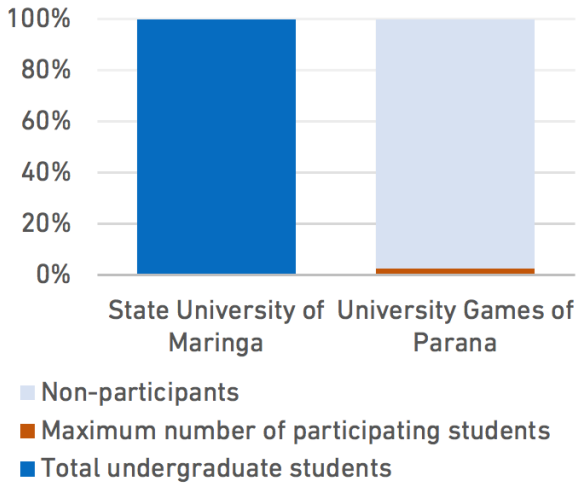

Figure 1: Students enrolled in undergraduate courses at UEM and maximum participation of students/athletes in the University Games of Paraná.

SOURCE: State University of Maringá, 2020; University Sports Federation of Paraná, 2019.

Therefore, at each edition of the University Games of Paraná, less than three percent of UEM undergraduate students take part in the state's official competition. On the other hand, the AAAs present themselves as an innovative model for promoting sports within the university environment. Academic Athletic Associations and Academic Leagues (created by a group of AAAs from the same university or Science Centre) are voluntary and amateur entities organised by academics themselves. Currently, there are twelve Athletic Associations at UEM, encompassing 39 of the 42 undergraduate courses offered by the institution. A total of 12,184 academics (97.55%) are represented by Academic Athletic Associations (see Figure 2).

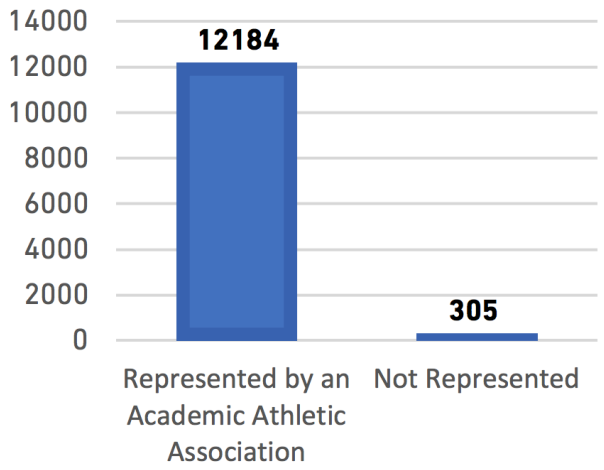

Figure 2: Academic Athletic Associations at UEM and undergraduate students represented.

SOURCE: State University of Maringá, 2020

Academic Athletic Associations organise internal competitions, sports training and other actions aimed at academics in their respective courses. Together with other Academic Athletic Associations from other universities in the city, the Maringá Athletic League (in Portuguese "LDA") was created. Its aim is promoting a municipal competition, the Inter-Athletic Associations Games of Maringá (in Portuguese "JOIA"), which are held annually and had their 11th edition in 2019. The event aims to develop and encourage sports practice in the university environment, in addition to bringing students together through social and sport exchanges. In this competition, sixteen recreational and non-traditional sports are offered (see Table 2).

Table 2: Sports encompassed by the Inter-Athletic Associations Games

MODALITIES	Maximum number of athletes per Academic Associations	
	Male	Female
Athletics	20	18
Basketball	12	12
Soccer*	23	-
Futsal	12	12
Handball	16	16
Billiards*	2	
Foosball*	2	
Poker*	2	
Truco Paulista*	2	
Judo	8	-
Swimming	18	16
Tennis *	4	4
Table tennis*	3	3
Volleyball	14	14
Beach Volleyball	3	3
Chess	6	6
TOTAL BY GENDER	147**	112**
TOTAL	**251**	

SOURCE: Maringá Athletic League, 2019
*Sports present only at the Inter-Athletic Associations Games
**Maximum hypothetical total number of students/athletes considering that the Billiards, Foosball, Poker and Truco Paulista (A typically Brazilian card game) teams would have competitors of only one gender
Note: Although the regulations of the Inter-Athletic Associations Games allow an athlete/student to participate in more than one sport, the same logic adopted to address the University Games of Paraná will be applied here.

The General Regulations of the competition do not establish a maximum number of sports in which students/athletes can participate. As a comparison, this study was based on the internal logic of the University Games of Paraná, which determines that students/athletes can participate in only one sport. Therefore, each Academic Athletic Association can count on a maximum number of 251 students/athletes (see Figure 3). In this perspective, it is important to highlight that some Academic Athletic Associations (such as the Academic Athletic Association of the Medicine course and the Academic Athletic Association of the Communication and Multimedia course, with 246 and 168 students, respectively) have lower numbers of students enrolled in their respective courses, when compared to the maximum number of students/athletes included in the competition according to the sports offered.

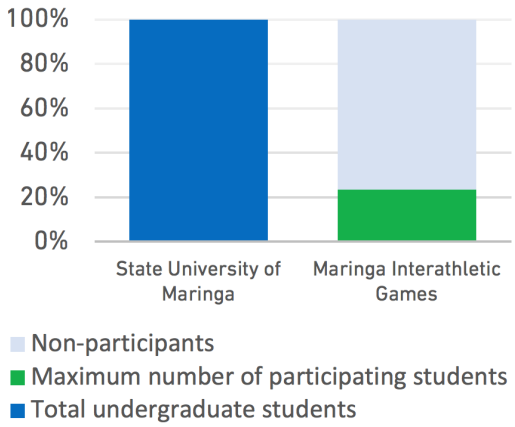

Figure 3: Students enrolled in undergraduate courses at UEM and maximum participation in the Inter-Athletic Associations Games.

SOURCE: Maringá Athletic League, 2019; State University of Maringá, 2020.

When analysing the numbers presented for the sports listed in the Inter-Athletic Associations Games in relation to the number of students enrolled in undergraduate courses at UEM, we found the coverage result of approximately 23.41%. That is, at each edition of the competition, almost ¼ of the academics (considering only undergraduate students) has the chance to take part in the competition.

The event allows participation of academics in some concomitant competitions, such as the Percussion Challenge and the Cheerleaders' Challenge. These events include students who were not selected for sports teams or do not wish to take part in sports competitions (Labronici et al., 2000; Parente, 2011; Rittner, 2013; Fiochi-Marques, 2019; Malagutti et al., 2020).
In a comparative analysis, although the mentioned competitions have different goals, the Inter-Athletic Associations Games are a more comprehensive competition in terms of general numbers (see Figure 4).

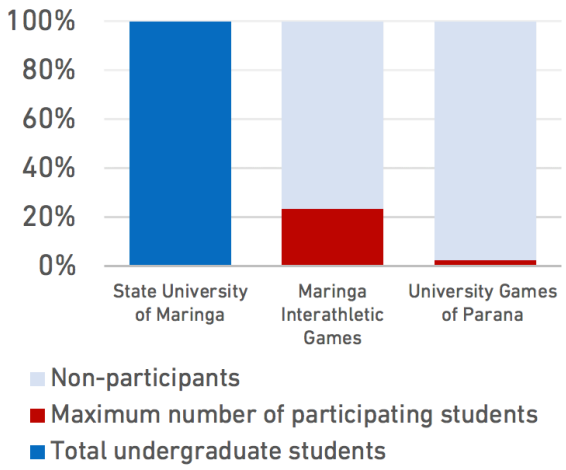

Figure 4: Hypothetical number of students enrolled in undergraduate courses at UEM and the maximum number of athletes in the Inter-Athletic Associations Games and the University Games of Paraná.

SOURCE: Maringá Athletic League, 2019; State University of Maringá, 2020; University Sports Federation of Paraná, 2019.

According to the official summaries of the University Games of Paraná, in 2019, UEM was represented by 167 students/athletes. Thus, it did not reach the maximum number established in accordance with the General Regulations of the competition. At the Inter-Athletic Associations Games of Maringá, according to the Maringá Athletic League, approximately 1,316 students/athletes previously registered for the sports took part in the event (University Sports Federation of Paraná, 2019b; Maringá Athletic League, 2019).

However, it is important to take into account the purposes of the competitions analysed in this study. At the University Games of Paraná, sports practice follows universally recognised rules. The competition aims to search for national and international representation in university sport events, thus seeking the best athletes/students through their performance (Starepravo, 2007; Starepravo et al., 2010).

At those competitions organised by the academics themselves, there is also the traditional sports practice and its universally recognised rules. Yet, their purpose is different, for they seek greater participation and, consequently, a more democratic involvement of students/athletes, since there are several activities, such as the different types of challenge previously mentioned (Fiochi-Marques, 2019; Malagutti et al., 2020).

CONCLUSION

Sports practice at the State University of Maringá is currently organised into two conceptions: a traditional one, represented by an official organ of the university, involving participation in competitions organised by the responsible state entity; and another autonomous one, with the organisation of events exclusively conducted by the academics and their Academic Athletic Associations and Leagues. It is also important to note that the two aforementioned entities also conceive the practice of university sport as a leisure and recreational activity.

The University Games of Paraná are a qualifying competition for bigger ones, and they seek the best results for representation in other university sport events. Although the Athletic Associations Games promote traditional sports practice, they have a different purpose once they seek the democratic participation of students/athletes in several possibilities in terms of performance.
The results of this research show that actions whose target public is university students should be better planned, since the main state competition has very little impact on UEM academics. As for the Inter-Athletic Associations Games, although they present relatively better numbers, compared to the University Games of Paraná, some UEM undergraduate courses are not represented by Academic Athletic Associations. Therefore, the competition does not manage to cover all academics enrolled in the university.

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DINAMIKA RAZLIČITIH MANIFESTACIJA UNIVERZITETSKOG SPORTA NA BRAZILSKOM UNIVERZITETU

Univerzitetski sport u Brazilu trenutno organizuju i vode pravne, ali i autonomne organizacije. Ova studija je imala za cilj analizirati učešće studenata dodiplomskih studija na Državnom univerzitetu u Maringi (UEM) u dvije različite manifestacije univerzitetskog sporta. Za analizu podataka smo koristili osnovnu opisnu statistiku. Prema tome, naglašavamo veću mogućnost učešća studenata u vlastitim događajima (23,1%), a u poređenju sa zvaničnim takmičenjima (2,45%). Zaključili smo da samostalno organizovana takmičenja mogu uključiti veći broj studenata, a u poređenju sa zvaničnim. Međutim, ona imaju ograničenja poput nedostatka reprezentativnosti nekih smjerova u studentskim organizacijama.

Ključne riječi: sport, univerziteti, takmičenja

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THE EFFECT OF CORE MUSCLE FATIGUE ON BIOMECHANICAL PARAMETERS DURING JUMP SERVE IN VOLLEYBALL

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ABSTRACT

The purpose of study was to analyse the effect of core muscle fatigue on changes in kinematic parameters during jump serve in volleyball. In this study, the participants were sixteen experienced male volleyball player volunteers, with an average age, height and body weight of 24.6 ± 1.8 years, 1.85 ± 1.6m and 79.5 ± 3.5kg, respectively. This study utilised two high-resolution digital video cameras, a drone video camera, three-dimensional calibration, 3D motion analysis software, a lactate analyser, a heart rate monitoring system, and a radar speed gun. Meanwhile, the eight kinematic parameters analysed at the approach, plant and jump phases showed that the ball speed decreased significantly in the fatigue condition, compared to the non-fatigue counterpart. There was a significant difference in the jump phase duration, step length and jump height variables for the fatigue and non-fatigue conditions during the jump serve in volleyball. Furthermore, the six kinematic parameters analysed in the maximal shoulder external rotation phase showed that a significant difference in fatigue and non-fatigue conditions was found in the shoulder external rotation and backward trunk tilt parameters. Meanwhile, in the maximum angular velocity phase in the upper limb joint, during the jump serve, it was found that the shoulder internal rotation variable decreases significantly in the fatigue condition, compared to the non-fatigue counterpart. Additionally, in the trunk rotation and forward trunk tilt, a significant decrease in the upper limb joint maximum angular velocity was observed in the fatigue condition during the volleyball jump serve.

Keywords: volleyball, sport biomechanics, core muscle, fatigue, jump serve

INTRODUCTION

Volleyball was initially created for recreational sports purposes, but now it is also a competitive sport. In addition, volleyball is a team sport where individual players must be able to master skills and tactics, supported by a high physical fitness level, both in the attack and defence conditions (Ficklin et al., 2014). Therefore, these players have to master six basic skills: service, receiving, passing, setting, blocking, and spiking. Jump height is the main performance in the volleyball game characteristics, and it is an important factor for a successful jump serve performance. Typically, jumps are used during the spike, block and service actions. A jump serve is a service technique performed by throwing the ball upwards with both hands from the court baseline, followed by a lower body ground reaction force while jumping as high as possible to hit the ball in the air towards the opponent's field (Tilp et al., 2008). The jump serve is characterised by a high toss, multistep approaches, take-off, maximal jump as well as a full

swing of both arms (Akarcesme et al., 2018). Recently, the jump serve has become a dangerous offensive weapon for the top volleyball teams, as a great spike server is able to produce a number of aces over the course of the match (Vaverka et al., 2016). An analysis of the services performed at the 2005 Men's European Volleyball Championship showed that the Spanish team used the jump serve more often at a 72% execution rate, compared to other serve types, while the French and Dutch teams used the serve at execution rates of about 63% and 58%, respectively. According to the International Volleyball Federation (FIVB), the average jump serve frequency increased from 63% at the 2004 Olympic men's tournament to 82% at the 2008 counterpart (Buscemi et al., 2019).
A study conducted by MacKenzie et al. (2012) regarding the spike vs. the jump serve for collegiate volleyball players showed similar speeds for male athletes (male jump serve 19.7 m.s-1 and male spike 22.4 m.s-1) but lower speeds for the female jump serve (13.2 m.s-1), compared to the spike (17.8 m.s-1). Meanwhile, a study on elite international volleyball spikers' front row spikes reported a mean impact ball speed of 27 m.s-1. In the jump serve, the ball position at impact is determined by the server's toss.
The stages in a volleyball jump serve are categorised above. During the approach phase, horizontal speed is developed and subsequently slowed down by planting one foot in front of the body (Reeser et al., 2010). The dynamic arm swing allows for greater momentum and ground reaction force to be generated. As stated in previous studies, the spike action is divided into three phases (the approach, plant, and jump phases) to enable a detailed analysis of the players' performances. Meanwhile, the previous studies' results showed that the main aspects influencing jumping performance are approach velocity, trunk countermovement, upper body support, arm swing, and knee extension angular velocity. The lower leg muscles are previously stretched after setting the foot through a cycle of shortening stretches, while the joint angle is reduced and the body is lowered to increase the distance during acceleration. Furthermore, the serve success is determined by several factors, including arm swing, jump height, upper body joint range of motion, and core muscle strength. With respect to the jump serve frequency at the international level of competition, Fuchs et al. (2021) reported an average number of jumps per game of 118-212 times. During a jump serve, a large number of jumps has a direct impact on muscle fatigue, primarily in the body's lower and core muscles, including the trunk and hip muscles, with the function of maintaining the spine and pelvis stability, as well as supporting the transfer of energy from large to small muscles during the activity (Wan et al., 2017). According to Hung et al. (2019), core stability is the ability to control the body's position and motion so as to produce optimal movement in activities. Becker et al. (2017) described core muscle stability as an integration of local muscles, single joint and multi-joint muscles to provide bodily stability, and produce efficient as well as effective movements.

PROBLEM AND AIM

During a sports activity, fatigue causes decreased muscle power generation, neuromuscular coordination, precise movement control, joint stability, muscle contraction, and reaction time speed. Fatigue is defined as a person's lack of ability to produce the required energy or the inability to sustain the energy produced to perform a targeted activity. Generally, muscle fatigue is defined as a reduction in a muscle's ability to generate power due to disconnected coordination in the chain of motion from the central nervous system to the muscle fibres.

According to Ozmen (2016), in soccer, core muscle fatigue has an impact on decreased performance during jump headings. The ball speed decreases after impact due to decreased hip and trunk forward velocities, as well as head extension angular velocity. Similarly, a study conducted by Baştiurea et al. (2014) on handball throwing showed a significant reduction in shoulder internal rotation, elbow extension angular velocity and horizontal abduction shoulder velocity after a muscle fatigue treatment was conducted. Meanwhile, in badminton, significant reductions in shoulder internal rotation, forearm pronation, elbow extension, and wrist flexion angular velocity were observed after muscle fatigue treatment, and this negatively influenced the jumping smash performance. However, this differed, compared to a study conducted by Vaverka et al. (2013) on table tennis, where a significant increase in ball speed during the forehand top spin stroke was reported after arm muscle fatigue treatment with maximum weight training, and only the ball accuracy differed.

All the jump serve movement aspects associated with the above-mentioned core muscle fatigue were biomechanical analysis variables of particular interest for this study's purpose.

METHODS

Method and Design

This study used a descriptive method, with a quantitative approach, using one-group pre-test and post-test design.

Participants

In this study, sixteen experienced male volleyball players, with an average age, height and body weight of 24.6 ± 1.8 years, 1.85 ± 1.6m and 79.5 ± 3.5kg, respectively, volunteered to participate in the research.

This study was approved by the local Ethics Committee of Universitas Pendidikan, Indonesia.

Fatigue Treatment

As a treatment for core muscles fatigue in the body, various core training types, including flutter kicks, reverse crunch, feet crossovers, plank knee-ins, scissor kicks, spiderman push-ups, side plank raises, mountain climbers, and sit-up cross punch exercises, were provided. All exercises were performed in one set until the point of fatigue was reached. Meanwhile, a heart rate (HR) monitoring system (Polar S 810İ Polar Electro OY, Finland) was fitted to each player before the fatigue exercise treatment. Each participant's resting HR and maximum HR values were also recorded.

Statistical Analysis

This study utilised the SPSS version 22.0 application software (SPSS Inc., Chicago, IL). Additionally, mean and standard deviation were calculated as initial data for further analysis on the normality, homogeneity and hypothesis testing. To test the hypothesis significance, a one-way analysis of variance approach was used at the significance level of $p < 0.05$.

The joints were tested using the Butterworth low-pass filter method approach at a 15 Hz cut-off frequency, determined by residual analysis techniques.

Kinematic Parameters

To analyse the volleyball jump serve kinematic parameters, a movement model design was formulated in accordance with the body's anatomical principle, as outlined below (Figure 2). The shoulder joint comprises three movements, internal-external shoulder rotation (A), shoulder abduction-adduction (B) and horizontal shoulder abduction-adduction (C). Meanwhile, the elbow joint comprised one motion characteristic - the elbow flexion-extension (D). The next movements are the forward-backward trunk tilt (E), left and right sideways trunk tilt (F) and hip and trunk rotation (G).

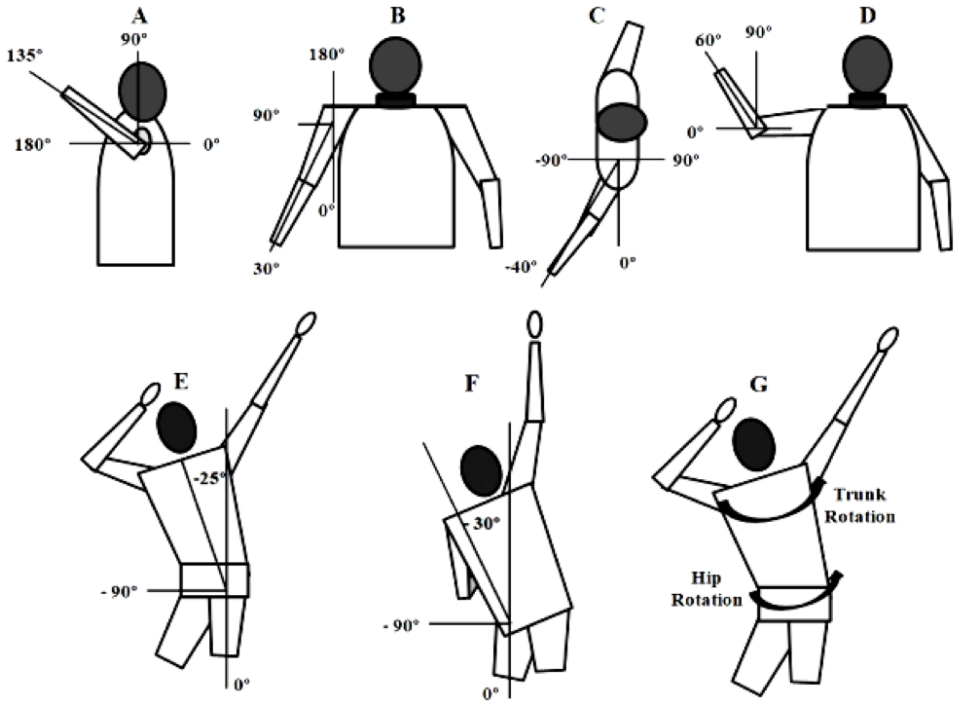

Figure 2: Kinematic parameters in the upper limb joints

Instruments

This study utilised two high-resolution digital video cameras (Sony Handycam HC-V400 Full HD, Japan), a drone video camera (DJI Phantom 4 Pro, China), one set three-dimensional calibration, 3D motion analysis software (Dartfish Pro, Switzerland), a set of manual markers, a lactate analyser (Accutrend plus kit GCT, Germany), a heart rate monitoring system (Polar S 810İ Polar Electro OY, Finland), as well as a radar speed gun (Bushnell Speed gun 101911, Italia).

Procedure

The ball speed was measured using a radar speed gun with a 100 Hz shutter speed, placed near the net at a distance of 45 cm outside the field's side line. Meanwhile, all jump serves were captured using three

high definition digital video cameras. To capture the jump serve performance movement, all three video cameras (Handycams) were operated at a 120 Hz nominal frame rate, with a 1/2000s shutter speed, and each was placed on a rigid tripod mounted at a 1.5m height. Video camera 1 was placed on the field's right side, at a distance of 3.5m perpendicular to the serve line, while video camera 2 was positioned behind the service line, perpendicular to the player's position, at a distance of 6m from the court's back line.
Meanwhile, video camera 3 was mounted on a drone positioned above the subject's head, in a vertical perpendicular position, at a 9m distance from the subject area. To obtain kinematic data, the subjects were instructed to warm up and practice the normal jump service. Subsequently, each subject was asked to perform a maximum jump serve and only 5 successful jump serve performances were recorded and used for further data analysis. In addition, calibration and data analysis processing were performed in three dimensions, using the direct linear transformation calibration structure method developed by Aziz Abdel.

RESULTS

Table 1 shows the means, standard deviation and significance values of the kinematic parameters in the approach, plant and jump phases during the volleyball jump serve.

Table 1: Kinematic analysis parameters in the approach, plant and jump phases during the volleyball jump serve.

Kinematic Parameter	Mean ± SD		p-value
	Fatigue	Non-Fatigue	
Ball velocity (m.s^{-1})	11 ± 1.7	20 ± 1.5	0.037*
Approach Phase Duration (s)	0.54 ± 0.03	0.52 ± 0.02	0.852
Planting Phase Duration (s)	0.22 ± 0.01	0.22 ± 0.03	0.767
Jump Phase Duration (s)	0.70 ± 0.05	0.61 ± 0.07	0.041*
Total Spike Duration (s)	1.47 ± 16.41	1.41 ± 0.06	0.812
Step Length (cm)	201.5 ± 13.16	262.4 ± 15.24	0.036*
Jump Height (cm)	78.54 ± 4.23	75.17 ± 5.13	0.038*
Spike Height (cm)	293.25 ± 6.05	279.54 ± 6.18	0.229

**Significant at p < 0.05*

The eight kinematic parameters analysed at the approach, plant and jump phases showed a significant decrease in ball speed during the fatigue condition (11 m.s-1), compared to the non-fatigue counterpart (20 m.s-1), with a p value of 0.037.

Furthermore, the data showed a significant difference in the jump phase duration (p = 0.041), step length (p = 0.038) and jump height (p = 0.034) variables in the fatigue and non-fatigue conditions during the volleyball jump serve.

Table 2: Kinematic parameters in the maximal shoulder external rotation phase during the volleyball jump serve

Kinematic Parameter	Mean ± SD		p-value
	Fatigue	Non-Fatigue	
Shoulder external rotation (°)	-122 ± 3.5	-169 ± 4.2	0.042*
Shoulder abduction (°)	101 ± 1.2	106 ± 1.4	0.203
Shoulder horizontal adduction (°)	7 ± 0.83	9 ± 0.96	0.312
Elbow flexion (°)	94 ± 1.1	102 ± 1.3	0.956
Backward trunk tilt (°)	16 ± 3.5	29 ± 3.1	0.033*
Left sideways trunk tilt (°)	19 ± 1.4	21 ± 1.6	0.229

**Significant at p < 0.05*

Table 2 shows the kinematic parameters' means, standard deviation and significance values in the maximal shoulder external rotation phase during the volleyball jump serve.
The six kinematic parameters analysed in this phase showed a significant difference between the fatigue

and non-fatigue conditions occurred in the parameters of the shoulder external rotation (p = 0.042) and backward trunk tilt (p = 0.033) during the volleyball jump serve.

Table 3: Kinematic analysis parameters on the maximum angular velocity in the upper limb joint during the volleyball jump serve

Kinematic Parameter	Mean ± SD		p-value
	Fatigue	Non-Fatigue	
Shoulder internal rotation (°/s)	1623 ± 3.5	2161 ± 4.2	0.052*
Trunk rotation (°/s)	561 ± 1.2	782 ± 1.4	0.087*
Hip rotation (°/s)	421 ± 0.8	429 ± 0.9	0.203
Elbow extension (°/s)	873 ± 1.1	995 ± 1.3	0.112
Forward trunk tilt (°/s)	162 ± 3.5	199 ± 3.1	0.029*
Left sideways trunk tilt (°)	185 ± 3.5	199 ± 3.1	0.198

Significant at p < 0.05

Table 3 shows the kinematic parameters' means, standard deviation and significance values of the maximum angular velocity in the upper limb joint during the volleyball jump serve.

According to the table, a significant reduction in the shoulder internal rotation variable occurred in the fatigue condition (1623°/s), compared to the non-fatigue counterpart (2161°/s), with a p value of 0.052. Additionally, in the fatigue condition, a significant decrease in the upper limb joint maximum angular velocity was found in the trunk rotation (p = 0.087) and forward trunk tilt variables (p = 0.029), compared to the non-fatigue counterpart during the jump serve.

DISCUSSION

Ball Velocity

This study's results showed a significant decrease in the ball speed during the fatigue condition (11 m.s-1), compared to the non-fatigue counterpart (20 m.s-1) during the volleyball jump serve. This is similar to the results of a study conducted by Ahmed (2013) on the a pitcher's throwing in baseball, where the ball speed experienced a significant decrease of about 23% in the fatigue condition, compared to the non-fatigue counterpart (128.9 km/h). Rusdiana et al. (2020) also reported a significant difference in ball speed of 80 km/h and 125 km/h during the jump heading in soccer, in fatigue and non-fatigue conditions, respectively. According to Ziv and Lidor (2010), the maximal ball speed had a significant positive correlation with the absolute stride length during a pitch (r = 0.69) but not with the relative stride length (% body height, % lower extremity length and % maximal open legs' width). In handball throwing, the transfer of impulses from the proximal to distal segments, including the hip, shoulder, elbow, wrist, and middle hand, is an important factor in achieving maximum ball velocity. According to Yanagisawa and Taniguchi (2020), 67% of ball velocity at ball release is explainable by the summation effects from the velocity of elbow extension and shoulder internal rotation. Meanwhile, Dinç and Ergin (2019) show a significant correlation for timing the maximal pelvic angle with ball velocity, indicating the best throwers.

Approach Phase

In the approach phase, during the jump serve's ready position, the server stands about 5 m behind the end line and holds the ball in the serving hand. The jump serve description for a right-handed server is given below. For a left-handed server, the foot and hand positions are expected to be on the opposite side. The ball toss occurs off the right foot, and the ball is tossed with the right arm, elbow extended and body leaning forward. Subsequently, the ball is intended for the serve from the left foot, preferable at a high point of release above the server's head because longer ball contact gives better control over the toss. A long step onto the left foot is performed to start the run-up (Sattler et al., 2015). In the run-up, the step from the left foot back onto the right foot is the longest and often covers a distance up to 80% of the server's standing height. Thus, an increase in this step's length implies the server is more skilled and also has more time and distance to decelerate the forward velocity and prepare for an upwards take-off. A study conducted by Reeser et al. (2010) showed that a longer step is related to a faster run-up, and this is in turn related to a higher jump as well as a faster serve to prepare for trunk rotation into the serve.

The upwards arm swing is completed prior to the extension of the legs because the arm swing makes a contribution to ground reaction forces early in the take-off before leg extension occurrs (Sarvestan et al., 2020). However, the end of the arm's upward motion has the capacity to also transfer vertically.

The final left foot plant occurs prior to take-off. As the foot is planted well ahead of the right foot at an angle to the end line, the arm swing nearing completion transfers the momentum to the rest of the body for take-off. Meanwhile, as the leg is extended, the trunk is also extended to maximise the ground forces. The timing of joint movements during take-off comprises shoulder flexion, trunk extension, and hip and knee extension. Özdal (2016) reported that the final movement to increase jump height is ankle plantar flexion, as the calf muscles contribute significantly to jump height. At take-off, the centre is raised in the body by full trunk and leg extensions and raising the arms to a near-vertical position at take-off. A skilled jumper is able to attain 60% of the total jump height by increasing the height of the centre of mass at take-off. Meanwhile, the mean horizontal velocity at take-off was found to be 3.23 m.s-1. In a related study on the jump serve, the centre of mass mean horizontal and vertical velocities at take-off were reported to be a bit lower, at 2.76 and 2.77 m.s-1, respectively (Challoumas et al., 2017). However, in this study, the mean values for top servers were horizontal velocities of 4.20 m.s-1 at the right foot plant, and 3.65 m.s-1 vertical velocity at take-off, while the centre of mass velocity at ball impact ranged from -0.33 to 2.76 m.s-1, indicating that some servers hit the ball on the way down and others hit it on the way up, as was also observed by Reeser et al. (2010) in front row spiking.

Jump Phase

The movement of upper extremities (body parts hitting the ball) happens entirely during this phase. The ball moves to a significant height of up to 10 m and then drops to a player contact position about 2 m on the court.

A study of the toss using either hand concluded that tossing with the serving hand utilised an increased range of motion in the hitting arm and trunk during the toss. These actions produce a longer lever arm and greater mass to create optimum velocity in the hand (Dinç & Ergin, 2019).

CONCLUSION

In this study, the eight kinematic parameters analysed at the approach, plant and jump phases showed a significant decrease in ball speed during the fatigue condition, compared to the non-fatigue condition. Furthermore, the data showed a significant difference in the jump phase duration, step length and jump height variables during the fatigue and non-fatigue conditions in the volleyball jump serve. The six kinematic parameters analysed in the maximal shoulder external rotation phase showed that a significant difference in fatigue and non-fatigue conditions was found in the shoulder external rotation and backward trunk tilt parameters during the volleyball jump serve. Subsequently, the six kinematic parameters analysed in the maximum angular velocity phase in the upper limb joint during the jump serve showed a significant reduction in the shoulder internal rotation variable during fatigue conditions, compared to the non-fatigue counterparts. In addition, a significant decrease in the upper limb joint maximum angular velocity was found in the trunk rotation and forward trunk tilt variables during fatigue conditions, compared to the non-fatigue counterpart during the volleyball jump serve.

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EFEKAT ZAMORA MIŠIĆA TRUPA NA BIOMEHANIČKE PARAMETRE TOKOM SKOK-SERVISA U ODBOJCI

Svrha ove studije je analizirati efekat zamora mišića trupa na promjene kinematičkih parametara tokom skok-servisa u odbojci. U ovoj studiji je učestvovalo šesnaest iskusnih odbojkaša - volontera sa prosječnom dobi, visinom i težinom od 24,6 ± 1,8 godina, 1,85 ± 1,6m i 79,5 ± 3,5kg. U studiji su korištene dvije digitalne video kamere visoke rezolucije, kao i video kamera pričvršćena na dron, trodimenzionalno podešavanje, softver za 3D analizu pokreta, analizator laktata, sistem za praćenje srčane frekvencije i ručni radar. U međuvremenu je osam kinematičkih parametara analiziranih tokom faze zaleta, zaustavljanja za odskok i skoka pokazalo da se brzina lopte značajno smanjila u stanju zamora, a u poređenju sa stanjem bez prisustva zamora. Značajna razlika je bila prisutna u varijablama trajanja faze skoka, dužine koraka i visine skoka za stanja sa i bez prisustva zamora tokom skok-servisa u odbojci. Nadalje, šest kinematičkih parametara analiziranih u fazi maksimalne vanjske rotacije ramena je pokazalo da je značajna razlika u stanjima sa i bez zamora otkrivena u parametrima vanjske rotacije ramena i naginjanja trupa prema nazad. U međuvremenu se otkrilo da se, tokom skok-servisa u fazi maksimalne ugaone brzine gornjeg zgloba ekstremiteta, varijabla unutrašnje rotacije ramena značajno smanjuje u stanju zamora, a u poređenju sa stanjem bez prisustva zamora. Uz to, kod rotacije trupa i naginjanja trupa prema naprijed, uočeno je značajno smanjenje maksimalne ugaone brzine gornjeg zgloba ekstremiteta u stanju zamora tokom skok-servisa u odbojci.

Ključne riječi: odbojka, sportska biomehanika, mišići trupa, zamor, skok-servis

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DIFFERENCES IN MOTOR ABILITIES BETWEEN PRESCHOOL BOYS AND GIRLS

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ABSTRACT

Lack of physical activity, or hypokinesis, has been addressed from various health-related aspects and documented in many studies worldwide. Hypokinesis is often associated with excessive weight and obesity, which is found even in preschool-aged children. The physical activity level and motor abilities of preschool children have been the subject of many studies in the past two decades. The purpose of the present study was twofold: to examine the differences in motor abilities between preschool boys and girls and to assess the level of their motor abilities. The results of the study indicate that statistically significant differences in motor abilities exist between preschool boys and girls. Preschool boys had better results in two tests: backwards obstacle course and bent arm hang, and girls had better results in the sit and reach test. The level of motor abilities for both boys and girls, compared to earlier studies, was lower in four tests for boys, and three tests for girls, but at the same time, it was higher in some other tests. The findings suggest that there is a lot of room for improvement in the level of PA, and consequently motor abilities in today's preschoolers. Preschool settings should provide many opportunities for preschool children in motor skills development.

Keywords: preschool children, physical activity, motor skills

INTRODUCTION

A modern way of life brings many advantages which include facilitating the life of people, and nobody can ignore the usefulness of modernisation, but it has the other side too. Lack of physical activity, or hypokinesis, has been addressed from various health-related aspects and documented in many studies worldwide (Knight, 2012; Kahan, 2015; Atkinson, Lowe, Moore, 2016; Gadžić & Nikolić, 2020). Some studies confirmed that physical inactivity is a major contributor to chronic disease and healthcare spending in the adult population of many countries (Janssen, 2012; Pratt et al., 2014). Another aspect of the hypokinesis problem is poor posture (Gadžić, 2016) and the often associated excessive weight and obesity, which is found even in preschool-aged children (Milosavljević, Armano, & Petrić, 2018). There is evidence that obesity, inactivity and physical activity may all be traced from childhood to adolescence and adulthood (Janz, Dawson, & Mahoney, 2000; Malina, 2001). Therefore, recent research has begun to focus on the importance of physical activity in the preschool age (Oliver, Schofield, Kolt, 2007). Considering physical activity (PA), it must be emphasised that the existing belief that young children are naturally active and require no systematic encouragement or instruction to have a healthy level of PA is not grounded. It has been argued that contemporary young children are less fit and less active than before (Stupar, Romanov, Kerić, Rubin, & Hrnjić, 2014; American Academy of Pediatrics, 2021). According to Brewer, childhood sedentary behaviour should be considered as a complex and systematic problem that emerged during the economic growth and globalisation from 1990. Before that time, movement was more or less ingrained

into everyday life, and in today's society, meeting physical activity recommendations no longer happens without planned efforts (Brewer, 2018). The PA level of preschool children has been the subject of many studies in the past two decades. Findings from meta-analysis demonstrated the wide variability in reported accelerometer-derived PA levels of preschool-aged children, and that limits a true understanding of the prevalence of physical (in)activity in this population (Bornstein, Beets, Byun, & McIver, 2011).

The differences between the PA level of preschool boys and girls were documented in many studies (Vale et al., 2010; Vanderloo et al., 2013; Czajka et al., 2015). Furthermore, other studies confirmed the differences between preschool boys and girls in motor abilities as well (Bala, 2002; Bala, Jakšić, Popović, 2009).

The purpose of the present study was twofold: to examine the differences in motor abilities between preschool boys and girls and to assess the level of their motor abilities.

METHODS

Participants

The sample consisted of 103 healthy preschool boys and girls (52 boys and 51 girls), aged 6.2 ± 0.23. For descriptive purposes, we measured the height to 0.1 cm and body mass to 0.1 kg in all children. Basic anthropometric measurements of boys are: body height 125.41 ± 5.64, body mass 25.97 ± 4.79, while the girls' measurements are: body height 124.13 ± 5.05, body mass 24.06 ± 4.22, respectively.
The study was conducted with parental written informed consent.

The sample of variables

A variable sample has consisted of seven motor ability tests adapted for children aged 6 to 7 (Bala, 2002). These tests include: standing broad jump (lower body muscular power), sit-ups (abdominal muscular endurance), plate tapping (upper body speed), backwards obstacle course (coordination), sit and reach (extent flexibility), 20-m sprint (running speed), and bent arm hang (upper body muscular endurance).

Statistical analysis

The following statistical procedures were conducted for the whole sample. Basic descriptive parameters: arithmetic mean (AM), standard deviation (SD), minimum (MIN), maximum (MAX), skewness and kurtosis, were calculated for all variables. An independent samples t-test ($p \leq .05$) was used to determine the differences between the two groups of participants.

RESULTS

Table 1 shows the results of descriptive statistics related to the motor abilities of preschool boys. A simple comparison of mean values for motor ability variables indicates that the participants from the preschool boys group had the average results which were similar to previous studies only in running speed (Bala, Jakšić, Popović, 2009; Krneta, Bala, Madić, 2017). However, the values of standard deviation indicate that the most heterogeneous results were obtained in standing broad jump and bent arm hang tests.

Table 1: Descriptive statistic of motor abilities for preschool boys

Variable	M	SD	Min	Max	Skew	Kurt
Standing broad jump	86.81	15.07	56.00	114.00	0.12	-0.49
Sit-ups	26.22	5.62	15.00	38.00	-0.06	-0.39
Plate tapping	20.46	3.86	13.88	29.28	0.45	-0.09
Backwards obstacle course	21.40	5.02	13.40	32.77	0.76	0.44
Sit and reach	22.91	3.74	15.00	30.00	-0.35	-0.37
20-m sprint	5.10	0.47	4.21	6.26	0.39	0.57
Bent arm hang	8.87	7.03	1.00	32.90	2.03	4.74

The results of descriptive statistics pertaining to motor skills for the group of preschool girls are presented in Table 2. The arithmetic means of their results are almost identical to the previous study in running speed only, just like in the boys' group, while other results are quite different (Bala, Jakšić, Popović, 2009; Krneta, Bala, Madić, 2017). The values of standard deviation indicate that the most heterogeneous results were obtained in standing broad jump, which is quite expected since that test estimates lower body muscular power which is highly genetically determined.

Table 2: Descriptive statistic of motor abilities for preschool girls

Variable	M	SD	Min	Max	Skew	Kurt
Standing broad jump	88.06	17.90	50.00	139.00	0.57	1.53
Sit-ups	25.65	5.65	16.00	35.00	-0.18	-1.23
Plate tapping	21.51	4.09	14.82	31.10	0.37	-0.32
Backwards obstacle course	25.29	5.44	17.61	36.51	0.33	-0.87
Sit and reach	25.97	3.43	18.00	34.00	-0.15	0.53
20-m sprint	5.25	0.46	4.24	6.13	-0.22	-0.06
Bent arm hang	6.09	4.41	0.00	15.97	0.62	-0.23

Table 3 shows the results of the t-test for independent samples that was used to determine the differences between the two groups of participants.
The findings revealed that there were significant differences between preschool boys and girls in three out of seven tested variables. Preschool boys had better results in the backwards obstacle course ($p = 0.01$) and bent arm hang ($p = 0.05$), while preschool girls were more successful in the sit and reach test ($p = 0.01$).
No significant differences were observed between the groups in standing broad jump ($p = 0.76$), sit-ups ($p = 0.69$), plate tapping ($p = 0.30$), and 20-m sprint ($p = 0.19$) tests.

Table 3: Results of a t-test for independent samples

Variable	Boys Mean	Girls Mean	*t*	Sig.
Standing broad jump	86.81	88.06	-0.30	0.76
Sit-ups	26.22	25.65	0.40	0.69
Plate tapping	20.46	21.51	-1.04	0.30
Backwards obstacle course	21.40	25.29	-2.95	**0.01**
Sit and reach	22.91	25.97	-3.39	**0.01**
20-m sprint	5.10	5.25	-1.33	0.19
Bent arm hang	8.87	6.09	1.874	**0.05**

DISCUSSION

Given the insufficient level of PA that today's children are experiencing, early identification of inadequately developed motor abilities seems to be crucial. Therefore, we decided to evaluate those abilities among preschool boys and girls.

The first purpose of this study was to examine the differences in motor abilities between preschool boys and girls, and the second one was to assess the level of their motor abilities.

The results of the study indicate that statistically significant differences in motor abilities exist between preschool boys and girls. Preschool boys had better results in two tests: backwards obstacle course and bent arm hang, and girls had better results in the sit and reach test. Our findings are similar to those of Bala (2003) and Bala et al. (2009) who found that preschool boys, of the same age (6-7), were better in coordination, running speed and upper body muscular endurance, while girls dominated in flexibility.

Almost identical differences in motor abilities between preschool boys and girls aged 6-7 were reported by an earlier study (Cvetković, Popović, & Jakšić, 2007).

Another study confirmed that preschool boys had better results in the majority of motor abilities, except in flexibility (Horvat, Babić, & Jenko Miholić, 2013). Somewhat different results were revealed by Aćimović (2013) who found that preschool children (age 6-7) differ in coordination and flexibility in favour of girls, while boys had the advantage in running speed, upper body muscular endurance and strength.

These results are from the region, and only a few international studies attempted to establish differences in motor abilities between boys and girls during the development phase. However, these minor discrepancies in results confirm that preschool girls have better flexibility and preschool boys have the advantage in body muscular strength and endurance, while coordination, as a complex skill, often remains equally distributed in both genders. The absence of complete difference between preschool boys and girls in motor abilities might be in the view that most differences in gross motor skills at that age in boys and girls are small (Hraste, Đurović, & Matas, 2009) and associated with differences in activity levels (Manios, Kafatos, & Codrington, 1999).

Concerning the secondary aim of the current study, evaluation of the motor ability level of both boys and girls, we made comparisons with some earlier studies.

A simple comparison of average results for the motor ability tests revealed that, over a decade ago, preschool boys had better scores in running speed, flexibility, lower body muscular power, and upper body muscular endurance (Cvetković, Popović, & Jakšić, 2007; Bala et al., 2009), but boys from the current study were better in coordination, upper body speed and abdominal muscular endurance. For the girls' subsample, it seems that the girls from earlier studies had better scores than girls from the present study in the same abilities as boys, except for running speed which was almost identical with a previous study (Cvetković, Popović, & Jakšić, 2007; Bala et al., 2009). These findings might be an indication that the motor behaviour of today's preschoolers is quite different and that children probably spend less time engaged in physical activity.

Since early childhood researchers suggest that both structured and unstructured physical activity are essential for proper physical, social and cognitive development (Hinkley et al., 2014), early childhood educators in preschool institutions must strive more in order to promote physical activity in early childhood settings.
Apart from preschool institutions, a significant number of early "sports schools" can play an important role in PA improvement. A substantial number of studies confirmed that children who attend additional sports activities achieve better results in motor tests (Privitellio et al., 2007; Matrljan, Berlot, Car Mohač, 2015; Bojanić et al., 2018; Breg, 2019).

CONCLUSION

This study was intended to examine the difference in motor abilities between preschool boys and girls. The findings of the present study revealed that the differences between the two groups of participants do exist in three out of seven motor abilities.

Boys were significantly better in coordination and upper body muscular endurance, while girls had a significant advantage in flexibility. The level of motor abilities of both boys and girls, compared to earlier studies, was lower in four tests for boys, and three tests for girls, but at the same time, it was higher in some other tests.

Since motor abilities largely rely upon an adequate level of PA, every effort made to shape children's positive attitudes about physical activity is as important as incorporating appropriate physical activity into the daily routine. These findings suggest that there is a lot of room for improvement in the level of PA, and consequently motor abilities in today's preschoolers. Preschool settings should provide many opportunities for preschool children in gross and fine motor skills development.

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RAZLIKE U MOTORIČKIM SPOSOBNOSTIMA DJEČAKA I DJEVOJČICA PREDŠKOLSKOG UZRASTA

Nedostatak fizičke aktivnosti, ili hipokinezija, iz različitih zdravstvenih aspekata je bio predmet brojnih istraživanja širom svijeta. Hipokinezija je često praćena prekomjernom tjelesnom težinom i gojaznosti koja je čak primijećena i kod djece predškolskog uzrasta. Nivo fizičke aktivnosti je također bio predmet mnogobrojnih istraživanja tokom posljednje dvije decenije. Cilj aktualnog istraživanja bio je dvostruk: ispitati razlike u motoričkim sposobnostima između dječaka i djevojčica predškolskog uzrasta i procijeniti nivo njihovih motoričkih sposobnosti. Rezultati istraživanja ukazuju da postoje statistički značajne razlike u motoričkim sposobnostima između dječaka i djevojčica predškolskog uzrasta. Dječaci predškolskog uzrasta su imali bolje rezultate na dva testa: poligon unazad i vis u zgibu, a djevojčice su bile bolje na testu dohvat u sjedu raznožno. Nivo motoričkih sposobnosti dječaka i djevojčica, u usporedbi sa ranijim istraživanjima, bio je niži kod četiri testa kod dječaka i tri testa kod djevojčica, ali istovremeno oni su imali i neke bolje rezultate na drugim testovima. Ova saznanja ukazuju da postoji dosta prostora za poboljšanje nivoa fizičke aktivnosti i posljedično motoričkih sposobnosti današnjih predškolaca. Predškolske ustanove treba da obezbijede više mogućnosti za predškolsku djecu kako bi se razvile njihove motoričke sposobnosti.

Ključne riječi: predškolska djeca, fizička aktivnost, motoričke sposobnosti

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PRONATOR TERES RUPTURE IN A RECREATIONAL TENNIS PLAYER

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ABSTRACT

A pronator teres lesion is a relatively uncommon sports injury often associated with a stroke and/or hit traumatic mechanism, and only reported in cricket and golf contexts. Herein we present an unusual case of pronator teres rupture in an amateur tennis player with a forehand stroke mechanism, including the diagnostic process and the approach. The patient presented to our facilities complaining of right anterior forearm tightness and pain. The clinical presentation was confirmed by magnetic resonance imaging (MRI). Conservative treatment was chosen and consisted of a relative rest followed by rehabilitative treatment until the patient returned to his previous activity four weeks post-injury. Pronator teres strains are the possible causes of forearm pain and tightness and can be related to tennis-specific actions.

Keywords: magnetic resonance imaging, forearm, pronator teres muscle, strain, muscle injury

INTRODUCTION

Pronator teres strains are a relatively unusual injury, often associated with a stroke and/or hit traumatic mechanism(Chen et al., 2001). The injury occurs when the muscle fibres cannot withstand the eccentric forces following a violent strike to the ball or, worse, the ground while holding the sporting club or racket. This injury has been previously reported only in cricket and golf players (Ficke, 2015; Niebulski & Richardson, 2015). The classical presentation of pronator teres strain includes mechanical pain exacerbated by active pronation and wrist flexion with ulnar deviation.

The pronator teres is one of the so-called medial epicondyle muscles that comprise the flexor wad of the forearm. This muscle consists of 2 heads which originate proximally from the medial epicondyle and attach distally to the shaft of the radius on its lateral surface, although anatomical variations may be present (Olewnik et al., 2018). The oblique orientation of its fibres enables its primary rotatory role as the main pronator of the forearm.

Based on electromyography (EMG) studies, the pronator teres assists not only with forearm pronation but with elbow flexion(Farber et al., 2009). Pronator teres forms the flexor-pronator mass along with flexor carpi radialis (FCR), palmaris longus (PL), flexor digitorum superficialis (FDS), and flexor carpi ulnaris (FCU), which all together provide functional stabilisation against valgus stress during active motion.

The role of pronator teres has been highlighted among others as the primary dynamic stabiliser and the most likely musculotendinous unit to be injured in medial epicondylitis(Park & Ahmad, 2004; Udall et al., 2009). Diagnosis is usually made using magnetic resonance imaging (MRI) in reported cases of the injury (Ficke, 2015; Niebulski & Richardson, 2015). Herein we present an unusual case of pronator teres rupture

in an amateur tennis player with a forehand stroke mechanism. This case includes background information on the anatomy and pathophysiology of pronator teres strains, description of the assessment process and the subsequent intervention programme that led to a successful return to participation.

CASE REPORT

A right-handed, 52-year-old amateur male tennis player presented to our facilities complaining of right anterior forearm tightness and pain. The patient described a specific mechanism of injury in his right elbow while playing tennis 48 hours earlier. The patient, a medical doctor, was playing recreational tennis twice a week and had no previous symptoms or significant medical history related to the elbow. Initial symptoms started during a second set of a match, immediately after a clean forehand shot. A sudden, sharp pain was felt in the upper third of the forearm, followed by progressive swelling at the pain site. An increasing forearm weakness forced him to stop playing. The physical assessment during consultation 6 days following the injury episode revealed an anteromedial forearm bruise, 2-3 centimetres below muscle insertion. Mild tenderness to palpation was elicited over the middle third of the anteromedial forearm, specifically over the course of the cubital aspect of pronator teres.

The pronator teres revealed significant weakness and an attempted "grip-and-pull" manoeuvre caused immediate discomfort. Resisted forearm pronation accentuated the perceived referred pain suggesting contractile tissue involvement. Elbow assessment for tender areas showed no tenderness at the medial epicondyle.

The range of motion (ROM) evaluation revealed a full extension and 130° of flexion, probably due to swelling from the acute state. Pronosupination movements were unrestricted, but the discomfort was reproduced by active pronation. The Tinel sign for median nerve was negative and there was no sign of medial elbow instability. The rest of the neurological and vascular examination was unremarkable.

An MRI study performed 3 days after the patient's initial presentation showed a fairly well-defined area of high intensity signal on the axial and coronal proton density weighted MR images with fat saturation, all suggesting a grade 2 injury of the pronator teres muscle with a representation of a focal partial tear adjacent to the myotendinous junction (Figure 1).

An increased signal affected the surrounding tissue representing an associated oedema. No other anatomically related structures, such as ulnar collateral ligament, median nerve or distal biceps, were involved. X-ray images were not obtained.The medical staff initially diagnosed the patient with pronator teres strain based on the symptoms and weakness with resisted forearm pronation and elbow flexion. The expected outcomes include complete healing of the muscle tear, with the corresponding scar tissue formation along the affected site. The patient was then treated with instrumental myofascial release, stretching, active release techniques, and post activity icing for the following two weeks.

The patient was recommended to avoid elbow strenuous activities for 3 weeks. Manual therapy for elbow ROM and forearm strengthening of the related flexor wad was initiated at 7 days and continued for 3 weeks. At the latest evaluation, at 3 weeks, his elbow and forearm were clinically normal with complete range of movements and no evidence of any strength deficit. He was able to perform his upper body strength and conditioning workouts with the same intensity as pre-injury, so the patient was released back to his previous activity. He was allowed to gradually return to playing tennis, starting with low intensity backhand and forehand strokes. Once he was able to hit the ball normally without any symptoms, he progressively assumed forehand strokes. Four weeks after his initial presentation, he resumed participating at his previous level, reporting to be symptom-free with no sense of weakness or loss of control.

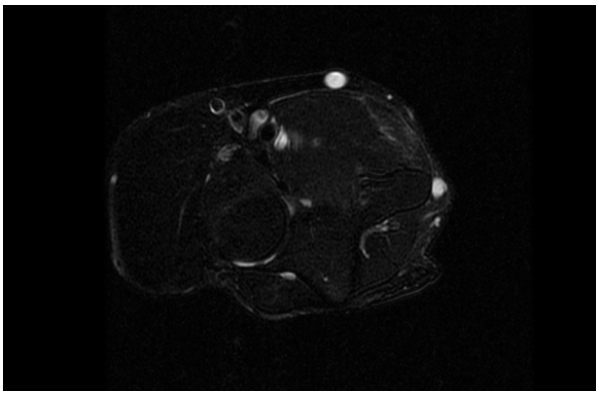

Figure 1a

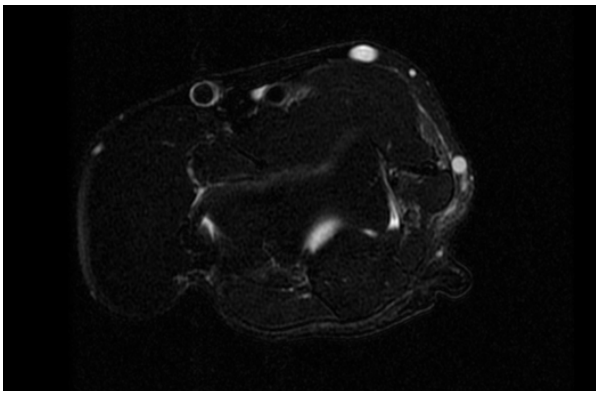

Figure 1b

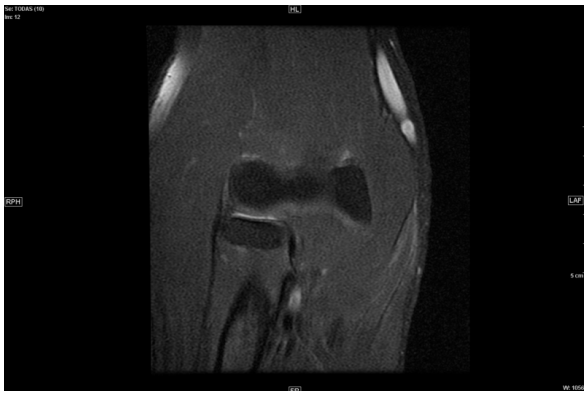

Figure 1c

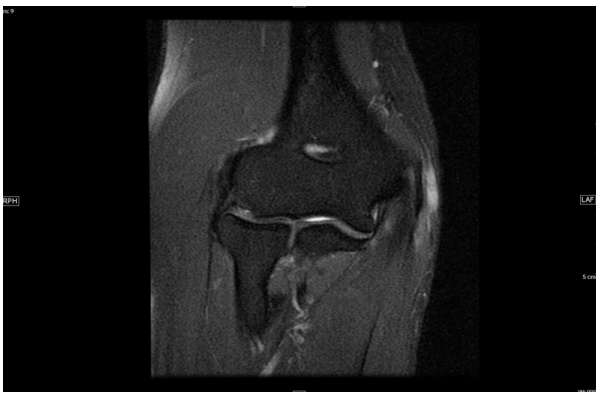

Figure 1d

Figure 1. (a, b) axial and (c, d) coronal proton density weighted MR images with fat saturation shown within. MR grade 2 injury of the pronator teres muscle with a focal partial tear (fibre disruption) represented by a fairly well-defined area of signal hyperintensity adjacent to the myotendinous junction.

Note: associated subcutaneous oedema.

DISCUSSION AND CONCLUSION

This case report describes the diagnostic process and approach to a patient suffering from a mild pronator teres strain. To the best of our knowledge, no previous pronator teres muscle strain following a forehand stroke has been described in recreational tennis in the past.

Isolated injuries to the pronator teres are not very common. Generally, these injuries have been the result of an abrupt pronosupination mechanism in stick/racquet sports(Fu et al., 2018; Orchard et al., 2016). Following these injuries, there is generally a positive outcome.

However, targeted treatment can be altered if diagnostic imaging is not used to confirm the affected structures. This case report describes the diagnostic process and approach to a patient suffering from a mild pronator teres strain.

Racquet size and weight, head weight, string tension or strike zone are considered factors influencing the impact stress at the elbow in a tennis context. Among those, technical aspects have shown to play a critical role with regard to physical demands imposed on this region. Poor forehand stroke mechanics have been highlighted as a cause of medial elbow stress, with a late ball strike, and with the racquet head behind the elbow at contact, being a significant contributor to medial epicondylitis (Ilfeld, 1992). All of this can be eventually exacerbated with an open-stance technique, which relies on rapid angular acceleration to the disadvantageous strike point. On the other hand, recreational tennis players may change their forehand shot more often than professionals and have been shown to require the pronator teres more than high-level tennis players(Reid et al., 2013), potentially leading to an increased risk of injury to this muscle.

This patient resumed his participation in competition for three weeks prior to his return to amateur tournaments. This timeline corresponds with previously reported data (Ficke, 2015; Niebulski & Richardson, 2015). While in this case the patient returned to play in a reasonable time frame, it is important to consider that the delayed diagnosis had the potential to keep the patient from returning to activity.

A differential diagnosis of medial elbow pain in tennis players includes ulnar collateral ligament sprain, ulnar neuritis, valgus extension overload with osteophyte formation and posteromedial impingement, medial epicondyle avulsion, and medial epicondyle tendinopathy(Kane et al., 2014; O'Holleran & Altchek, 2006).

Our above-described experience may enlarge this list with isolated pronator teres muscle strain.
In our case of a pronator teres strain, conservative management yielded good clinical outcomes. A follow-up MRI at 8 weeks post-injury demonstrated scarring of the muscle with resolution of the oedema and fluid collection.

Due to the existing gap in the literature, the approach to this rare entity should be individualised. Patient characteristics, such as level of activity and age should be considered, as should the degree of fibres involvement. MRI has shown to be a convenient method for localising the site and the extent of injury when a pronator teres strain is suspected. More high-quality evidence and well-designed studies are desirable to determine the optimal approach to these injuries.

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PUKNUĆE PRONATOR TERESA KOD REKREATIVNOG TENISERA

Povreda pronator teresa je relativno rijetka sportska povreda koja se često povezuje sa traumatičnim mehanizmom zamaha i/ili udarca, a zabilježena je samo u kontekstu kriketa i golfa. Ovdje prikazujemo neobičan slučaj puknuća pronator teresa kod tenisera - amatera, a sa mehanizmom forhend udarca uz dijagnostički proces i pristup. Pacijent je došao u našu ustanovu žaleći se na napetost i bol u desnoj prednjoj podlaktici. Klinička slika je potvrđena magnetnom rezonancom (MRI). Odabrano je konzervativno liječenje koje je obuhvatalo relativni odmor, a zatim rehabilitacijski tretman sve dok se pacijent nije vratio svojoj prethodnoj aktivnosti četiri sedmice nakon povrede. Naprezanje pronator teresa je mogući uzrok boli i napetosti podlaktice i može biti povezano sa aktivnostima koje su svojstvene tenisu.

Ključne riječi: magnetna rezonanca, podlaktica, pronator teres mišić, naprezanje, povreda mišića

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DEVELOPMENT OF PHYSICAL CULTURE AS A SOCIAL IMPERATIVE IN THE SYSTEM OF VALUE ORIENTATION OF YOUNG PEOPLE IN THE REPUBLIC OF SERBIA

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ABSTRACT

Bearing in mind that we do not have new facts about the position of young people on basic social values and their moral orientations, we researched the moral system with our young population. That is why we should get an insight into the attitude of young people towards basic social values and what, in their personal opinion, that value system looks like. The conducted analysis showed that health is the greatest value for student youth. Physical culture is at the very bottom. The main factors for motivating students towards physical culture have been identified - primarily the preservation of health. The research enabled the elaboration of a unique typology of students, according to their attitude towards physical culture and sports.

Keywords: physical culture, value system, educational policy

INTRODUCTION

Modern Serbian society is in the process of socio-economic and political changes - in a word, in transition. These changes, undoubtedly, change psychology, value orientations and people's behaviour. Young generations, as the most active and receptive component of the social organisation of society, are most exposed to these changes. Regardless of the exposure to change, there remain social values whose significance is not questioned. One of those values is physical culture (Nešić, 2014).

Physical culture is the subject of many years of different interpretations of terms in the academic and professional milieu. According to the university professor Pavle Rubin, physical culture is a conscious, planned, free, purposeful as well as creative social activity for learning and managing the material and spiritual goods of human physical activities, structured as physical education,

sports and sports recreation.
The fact that is indisputable in theoretical considerations is the role of state institutions to enable strategies and laws, in the legal sense, to implement certain specific measures so that young people can develop properly in the health, psychological and sociological sense.

It is in the interest of every state for its citizens to be able to work and be healthy because the economic power of every society is based on that. The larger the number of healthy and able-bodied population, the greater the possibility of economic development of that society (Dragosavljević, 2006)

There is a question of how much physical culture, sports or mass sports are practiced on the social-institutional level and in the appropriate cultural context, i.e., how value criteria are established according to physical education, health and physical appearance as well as spontaneous play; hence, the attitude towards one's own and external nature (Božović, 2008)

In this paper, the authors understand physical culture as an activity aimed at preserving their own health, developing physical and spiritual abilities, comprehensive training and social adaptation as well as achieving maximum results through physical education, physical exercises and competitions that require physical strength in conditions of rivalry.

In a modern society, the need for healthy and physically fit future professionals is growing. In this regard, it is especially important to work with high-school and student youth to form regular needs for physical culture.

At the same time, we should not ignore the fact that physical education has been abolished as a compulsory subject at the faculties since 1998, and that the democratic system and the Bologna Declaration impose completely different principles regarding the programming of the teaching process. Unlike the period in which society imposed the method and content of conducting physical education classes, modern society allows the right to choose and is based on principles that rely on interests (Krylova, 2008; Ivanova, 2019).

University professors Kuljić and Koković suggest advocating for the affirmation of physical culture as a way of life that would be supported by the state and social institutions that do not have to be directly related to sports, but which deal with the development of economy, social hygiene, culture as well as education (Kuljić, Koković, 2012)

In order to be able to create and implement measures for the formation of the mentioned regular needs, it is necessary to determine the attitudes of student youth about a healthy lifestyle and occupation in physical culture.

Due to all the above, in the period from March to April 2016, a research was conducted at the universities in Novi Sad and Belgrade.

This research is very current and is conditioned by the objective necessity of re-examining the place and role of a healthy lifestyle and the attitude towards physical culture among young people.

The imperative of the society is to take care of the physical health of its citizens, from the earliest age of children, youth, the working population, the elderly as well as people with disabilities. The formation of healthy habits in children is a prerequisite for a quality life, develops responsibility, organisation and meticulousness, which is a significant advantage for proper functioning in the work environment, in the family and among friends.

This is supported by the International Charter on Physical Education, Physical Education, Physical Activity and Sport, adopted in November 2015 at the 38th session of UNESCO, which primarily emphasises the health benefits of physical activity, inclusion of persons with disabilities, protection of children, the role of sport for development and peace, as well as the need to protect the integrity of sport from doping, violence, manipulation and corruption.

This document is the legitimate successor to the UNESCO International Charter on Physical Education and Sport, originally adopted in 1978. (https://unesdoc.unesco.org/ark:/48223/pf0000235409)

Starting from the principles established in the most important international documents, including the European Charter of Sport, the Code of Sports Ethics, the White Paper on Sport of the European Union, etc., the National Strategy for the Development of Sport in our country was adopted.

Playing sports and physical education are the basic human rights of all citizens of the Republic of Serbia, and the Republic of Serbia guarantees the realisation of these rights. Public authorities in the field of sport at all levels are expected to take measures to ensure that all citizens have the opportunity to engage in sport, and, where necessary, to take additional measures to help young talented people, but also people with disabilities, either individuals or groups, to make effective use of that opportunity.

The Strategy for the Development of Education in Serbia until 2020 states that the Serbian pre-university education system "does not monitor the quality of educational effects of education, but various indicators (e.g., the system of youth values, cultural needs and habits of students, ways of spending free time, models

for identification, type and frequency of violence in schools, etc.) say that the educational function was neglected at the mentioned levels of education", which physical culture largely had through physical education classes. The same Strategy states that "students do not have a dominant value system that promotes conscientious and persistent work, ethics, civic responsibility towards oneself, others and one's own environment".

Values can be defined in many ways and mainly relate to the concept of personal and social desirability. In addition to this fact, the study of value systems should take into account the relative stability of value orientations, their generality, motivational power as well as hierarchical structure within different value categories (Pantić, 2003).

In this context, values can be defined as "relatively stable, general and hierarchically organized characteristics of individuals (dispositions) and groups (elements of social consciousness), formed by the interaction of historical, current-social and individual factors, which due to such attributed desirability, direct behavior of individuals towards certain goals."

A well-known value researcher, Milton Rokeach, identifies two important value functions. One of these functions represents the standards that govern our behaviour, while the other, which we call motivational, concerns the component that expresses our striving for value (we strive, for example, to be honest and in solidarity). In this sense, the pursuit of fulfilment is a human need (Rokeach, 1973).

That is why, today, it is extremely important to shape the physical education of future specialists and direct the pedagogical process towards the education of the most important universal values among young people. Prospects for further research are finding mechanisms to improve the cultural value of physical culture in the educational space (Ivanova, 2019).

METHODOLOGICAL FRAMEWORK

Research methods

The paper combines a qualitative and quantitative methodological approach, the so-called triangulation method.

Techniques and instruments were selected within a descriptive research method. Analytic-synthetic and statistical methods were applied, as well as content analysis.

Research instrument

In order to gain a better insight into the place of physical culture in the value system of student youth, we modelled and conducted a survey entitled "Physical culture in the value orientation system of young people in the Republic of Serbia." We modelled the questionnaire in four levels:

1. health in the value system of students and the connection between this value and engaging in physical activities;
2. the character of the student's attitude towards engaging in physical culture;
3. the motive of student youth towards physical activities and their influence on the development of professional, morally voluntary activities;
4. typology of students based on the attitudes towards physical culture.

Research sample

The survey included 385 students at state and private universities in Novi Sad and Belgrade, selected by random selection. The survey was anonymous and conducted on a voluntary basis at their faculties.

The aim of the research was to determine the existence and place of physical culture in the system of value orientation of young people.

Based on the subject and aim of the research, the following tasks were set:

1. Examine the place of health in the student's value system and the relationship between this value and those engaged in physical activities;
2. Determine the character of the student's attitude towards physical culture;
3. Highlight the motives of student youth for engaging in physical activities and their impact on the development of professional and morally voluntary activities;
4. Execute a typology of students based on students' attitude towards those engaged in physical culture.

Hypotheses

H1. There is a conceptual inconsistency of young people's attitudes about a healthy lifestyle, the value of physical culture and actions to achieve the goal - a healthy lifestyle and good physical appearance.
H2. The values of health and healthy lifestyle do not correspond to the values of physical culture.
H3. The most pronounced motive for engaging in physical activities is good physical appearance and a way of maintaining health.
H4. Physical culture influences the development of voluntary qualities in students.
H5. The most common type is an amateur athlete.

RESEARCH RESULTS WITH DISCUSSION

The results of the research showed that in 65% of the respondents, health stands out as the most important value. It is interesting that we obtained the data by further analysis that out of 65% of students who single out health as the most important value, only 36% of them do some physical activity, while 64% of them do not have any physical activity. The research also showed us that young people, who are included in our research, do not see any connection between health and physical culture, without thinking about the need to maintain and support health. Despite such a high place of health in the value system, young people are passive towards physical culture.

The research further showed that a large percentage of respondents have good physical appearance (33%) among the most important factors in life. Out of this percentage, 44% of young people included in the research are engaged in physical activities, 56.4% neglect physical activities, which are among the most important for maintaining good physical appearance. The obtained results are, in our opinion, paradoxical. A large percentage of students do not see physical culture as one of the ways to achieve and maintain good physical appearance.

The answers of the respondents indicate the fact that modern young people do not see the connection between physical readiness for work and engaging in physical activities, although 38% of them practice some type of physical activity.

76% of the surveyed students believe that they adhere to a healthy lifestyle. More than half (53.8%) are engaged in some physical activity and 46.2% do not practice any physical activity. These data suggest that, for a large number of respondents, a "healthy lifestyle" does not mean engaging in physical activities.

After the research, we can talk about the inconsistency of young people's attitudes about a healthy lifestyle, the value of physical culture and actions to achieve the goal - a healthy lifestyle and good physical appearance. These results confirm our hypothesis H1.

The reasons for such results can be found in objective and subjective factors.
- Objective factors:
o lack of funding and state support for physical culture development programmes;
o social stratification of modern Serbian society;
o age characteristics of students' attitudes towards physical culture.
- Subjective factors:
o low level of awareness of young people about physical culture, misunderstanding of the concepts of sports and physical culture, as well as underestimation of their basic functions and moral values;
o personal characteristics: laziness, lack of will, etc.
o non-existence of a family tradition in physical culture and sports.

Motivation is of great importance for forming a positive attitude towards physical culture. We asked them "How would you characterise your aspirations for physical culture and sports?" The most important motive was maintaining the beauty of the body and enhancing and preserving health - 15.5% and 15.3%. The motive for improving physical development is ranked slightly lower - 12.8% and the possibility of emptying 11.9%. The results of the research confirm our third hypothesis.

Other motives for engaging in physical culture and sports are ranked as follows: the way of training willpower - 10.8, interesting way of spending free time - 7.5, the way of developing physical qualities - 7.5, the way of examining moral values through training - 4.2, vital need, necessity - 3.4, by nature I am an active person - 3.3, achieving high results - 2.5, the possibility of socialising with peers 2.3, the way for forming new acquaintances with the opposite sex - 1.6, following sports fashion 0.8 as well as childhood habits without great satisfaction 0.3%.

Despite their assumptions about health and a healthy lifestyle, student youth in reality do not show much interest in physical culture.

The obtained results can be used for the elaboration of programmes for the implementation of physical culture at universities, in the search for ways to attract students towards this type of activity.

In order to understand why student youth have a low interest in physical culture and what is the importance of physical education classes at school for young people, we examined the factors that determine physical activity.

The results of the research showed that the most significant are social factors (moral satisfaction - 18.5%; reduction of general fatigue - 9.4%), physical factors (preservation of health - 21.8%; physical development - 18.8%), mental factors (reduction of mental tension - 11%). We can also single out the factors: self-belief - 14.3% and increase in mental ability - 3.5% as very important factors for students who choose them to engage in physical activities.

In order to gain a full idea of the character and content of physical culture as a value orientation of student youth, we also examined the impact of physical activity

on the development of character traits.

The obtained results show that the assessments of the impact of physical activity on the development of character traits are evenly distributed and that in most cases, they are below 4. We have divided character traits into the following categories: professional (attention, operability, initiative, persistence, independence, perseverance), inclination towards the goal (endurance, perseverance, self-control, security) and moral (honesty, workaholism, discipline, resilience). From the results, it is quite clear that physical culture influences the development of voluntary qualities, such as endurance, perseverance and self-control, which confirmed our fourth hypothesis.

The last aspect of the research was to determine the dependence of physical activity on the social environment of the student. The results allowed us to perform the following typology of respondents: professional athletes - 7%, amateur athletes - 44%, recreational athletes - 12%, model athletes - 15% as well as nostalgic athletes - 22%. It is important to note that the derived classification represents the basic types of students according to the attitude towards physical culture and sports. The obtained results confirmed our fifth hypothesis.

CONCLUSION

Based on the conducted research, we can determine the place and role of physical culture in the structure of students' value orientation. The analysis of the data obtained by the research indicated that health is the greatest value for student youth. Physical culture, as a value in relation to health, is on a much lower scale, at the very bottom. There is a certain paradox throughout the research - despite the fact that most students value health and a healthy lifestyle the most, they still do not make any efforts to reach such a lifestyle and are passive towards physical culture. It turned out that this is the result of weak motivation to engage in physical activity for economic and social reasons, and it seems to us that it is due to the lack of understanding the importance of the role of physical culture and its function in human life.

The basic factors of students' motivation for physical culture have also been determined - first of all, it is the preservation of health. Factors related to the effectiveness of physical activity and the impact of engaging in sports on the development of young people's character traits were also assessed.

The research enabled us to develop a unique typology of students according to their attitude towards physical culture and sports: professional student, recreational student, model student as well as nostalgic student. The role of physical culture for each research participant is subjective. For some, physical culture has an important role, it is a way of life; for others, it is one of the ways to preserve health and support good physical condition.

We are of the opinion that all legally defined actors must continue with the process of actively directing young people towards physical culture through the provision of institutional and non-institutional conditions for engaging in physical activity. In that way, the supporting system of youth values towards physical culture, physical education, as well as education and health can be influenced.

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RAZVOJ FIZIČKE KULTURE KAO DRUŠTVENOG IMPERATIVA U SISTEMU VRIJEDNOSNE ORIJENTACIJE MLADIH U REPUBLICI SRBIJI

Imajući na umu da nemamo novih činjenica o stavu mladih prema osnovnim društvenim vrijednostima i njihovim moralnim orijentacijama, istraživali smo moralni sistem naše mlade populacije. Zato trebamo dobiti uvid u stav mladih prema osnovnim društvenim vrijednostima i kako, prema njihovom ličnom mišljenju, taj sistem vrijednosti treba izgledati. Provedena analiza je pokazala da je zdravlje najvažnija vrijednost za mlade studente. Fizička kultura je na samom dnu. Identifikovani su glavni faktori motivacije studenata za fizičku kulturu, a prvenstveno očuvanje zdravlja. Istraživanje je omogućilo obrazloženje jedinstvene tipologije studenata, a prema njihovom stavu ka fizičkoj kulturi i sportu.

Ključne riječi: fizička kultura, sistem vrijednosti, obrazovna politika

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FACTORS ASSOCIATED WITH PHYSICAL INACTIVITY AND SEDENTARY BEHAVIOR IN STUDENTS

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ABSTRACT

Objective: To verify the prevalence of physical inactivity and sedentary behaviour as well as the associated factors in students. **Methods:** Cross-sectional, analytical, school-based study. The sample was selected for convenience, made up of 50 students of both genders, enrolled in a Full-Time High School Centre in the city of Teresina-PI. Sociodemographic and economic variables, the level of physical activity, sedentary behaviour, smoking, and alcohol consumption were considered. Descriptive frequency statistics, association tests and unadjusted odds ratio were performed with a 95% confidence interval. **Results:** The prevalence of physical inactivity was 89.8% and sedentary behaviour was 45.8%. A negative association between the middle/low social class and sedentary behaviour was found; therefore, middle/low class students have a 75% reduced chance of presenting sedentary behaviour (95% CI: 0.076 - 0.859) when compared to the middle/upper class. **Conclusion:** The study's findings indicated a high prevalence of physical inactivity and sedentary behaviour among students of both genders, with an association between the middle/lower class and sedentary behaviour, which suggests that low-income people tend to use screen devices for a reduced time.

Keywords: physical activity, sedentary behaviour, students, adolescents

INTRODUCTION

Physical activity practicing brings numerous benefits to health and has been included in the physical activity realisation in free and global time as means for locomotion, domestic occupations, and leisure (DHHS, 2008).
However, it is noticed that adolescents have been reducing this practice, increasing physical inactivity which is a health problem seen as a risk factor for several diseases, such as mellitus diabetes, obesity, cardiovascular diseases, and other diseases (Lee et al., 2012). Furthermore, it is possible that it is considered as a stimulating factor to other habits considered unhealthy. (Abreu et al., 2011).
Physical inactivity prevalence in students from the State of São Paulo was 19.3% for males and 64.7% for females (Zanchetta et al., 2010). The growth of this condition increases with age (Vargas et al., 2013; Tigbe et al., 2011). Tabagism and alcoholic drinks intake are other public health problems found earlier among the adolescent population and may be related to lifestyle,

familiar and social context in which the young person is included (Abreu et al., 2011).
Few studies address the physical inactivity association with risky behaviours, such as tobacco and alcohol in adolescent students. In this context, these data are worrisome, since risk factors incorporated in adolescence tend to remain in adult life. In this sense, it is necessary to evaluate and plan effective public policy strategies focused on preventing these risk factors and promoting actions in the school environment.
Therefore, this research aims to verify physical inactivity prevalence and sedentary behaviour as well as the associated factors in adolescent students.

METHODOLOGY

This study is a cross-sectional and analytical, school-based research.The sample was composed of 50 adolescent students, males and females, selected through convenience, enrolled in a Full-Time High School Centre – FTHSC (Centro de Ensino Médio de Tempo Integral - CETI) located in the northern area of the city of Teresina-PI, belonging to the public state network, provided by the State Education Secretariat (Secretaria Estadual de Educação

- SEDUC). The school was chosen randomly, by drawing lots (among 22 schools). Students aged between 15 and 18 years old and with regular attendance in classes were included. Students who did not attend school on the days scheduled for data collection, pregnant students and those with orthopaedic problems that made the anthropometric assessment unfeasible were excluded.

Initially, a visit to the school management was made in order to present the research project and guide students on the procedures of data collection. The date and time for data collection occurred according to the School Unit calendar, in September 2019. Four physical education professionals, who received previous training, were involved. Two instruments were used for collecting data. For economic classification criteria, the questionnaire of the Brazilian Association of Research Companies was applied (ABEP, 2013).

The National School Health Survey (PeNSE) questionnaire was applied in four modules. Sociodemographic characterisation involved questions related to the mother's age, sex, race/colour, and education. The module for physical activity level assessment took into account the days and duration of physical activity such as: commuting to school on foot or by bicycle on the way back and forth, school physical education classes and physical activities practiced during the shift out of school. Responses referred to physical activity accumulation performed in the last seven days prior to the survey. Adolescents were considered active when they accumulated ≥ 300 minutes of physical activity in the last week, and those who practiced < 300 minutes were considered inactive. Regarding sedentary behaviour questions, those who accumulated more than 3h/day in the week were considered sedentary. The tabagism variable was also extracted (Brazil, 2016).

Regarding alcohol consumption, the Test for the Identification of Problems Related to Alcohol Use (Teste para Identificação de Problemas Relacionados ao Uso de Álcool - AUDIT) was proposed; it is an instrument of assessment for pattern alcohol use adapted and validated in Brazil (Méndez, 1999). As for the statistical analysis, data were stored in the statistical program Statistical Package for the Social Sciences (V18.0; SPSS Inc., Chicago, IL, USA).

Descriptive frequency statistics were performed. Association tests and unadjusted odds ratio with a 95% confidence interval (CI) were also performed. Anonymity and autonomy were guaranteed to all students involved in the research in order to preserve and comply with ethical principles. All of the students delivered the Term of Free and Informed Consent and the Term of Free and Informed Assent. It is worth mentioning that ethical precepts based on the National Health Council (NHC) Resolution 466/2012 were followed.

This study is the pilot of a larger research, and the research project was approved by the opinion No. 3,408,857 and CAAE 15612819.8.0000.5214 by the Ethics and Research Committee of the Federal University of Piauí (CEP/UFPI). This research offered the least possible risks; anthropometric assessments were carried out individually in appropriate rooms to minimise embarrassment or intimidation.

RESULTS

A sum of 49 students from a public integral high school answered the questionnaires. The results are found in Table 1. The sample showed that 63.3% of adolescents were female, 51% lower aged ones were 16 years old, and 85.7% the most prevalent race was not white. Cigarette use was 30.6%, and 89.8% of students are at a low risk for alcohol dependence. As for income, 59.2 %% of adolescents are part of a family with low/medium income, earning lower than three minimum wages. Regarding physical activity level classification, 89.8% of students are inactive, and 45.8% presented sedentary behaviour.
No association was found in relation to the independent variables seen as risk factors for physical inactivity (Table 2).

Table 1: Adolescents characterisation from Teresina - PI, 2019.

Variables	n	%
Gender		
Female	31	63.3
Male	18	36.7
Age		
> 16 years old	24	49.0
≤ 16 years old	25	51.0
Race/Colour		
White	7	14.3
Non-white	42	85.7
Social Class		
Middle/Low	29	59.2
Middle/Upper	20	40.8
Tabagism		
Yes	15	30.6
No	34	69.4
Alcohol Consumption		
Harmful/Dependency	5	10.2
Low Risk/Risk	44	89.8
Physical inactivity level		
Inactive (< 300 min.)	44	89.8
Active (≥ 300 min.)	5	10.2
Sedentary Behaviour		
Yes (> 3h/day)	22	45.8
No (≤ 3h/day)	26	54.2

Source: created by authors. Race/Colour = White; Non-white (brown, black, indigenous). Middle/Low class = C, D, E. Middle/Upper class = A, B.

The sample showed that 63.3% of adolescents were female, 51% lower aged ones were 16 years old, and 85.7% the most prevalent race was not white. Cigarette use was 30.6%, and 89.8% of students are at a low risk for alcohol dependence.

As for income, 59.2 %% of adolescents are part of a family with low/medium income, earning lower than three minimum wages. Regarding physical activity level classification, 89.8% of students are inactive, and 45.8% presented sedentary behaviour.
No association was found in relation to the independent variables seen as risk factors for physical inactivity (Table 2).

However, there was a negative association between the lower middle class and sedentary behaviour; thus, people in this class have a 75% reduced chance of presenting sedentary behaviour (95% CI: 0.076 - 0.859) in relation to higher middle class students (Table 3).

Table 2: Physical inactivity and associated factors in students from Teresina - PI, 2019.

	Physical Inactivity Level						
	Inactive		Active		OR	CI: 95%	p-value
	n	%	n	%			
Age							
> 16 years old	21	87.5	3	12.5	0.609	0.092 - 4.007	0.606
≤ 16 years old	23	92.0	2	8.0	1		
Gender							
Female	28	90.3	3	9.7	1.167	0.176 - 7.736	0.873
Male	16	88.9	2	11.1	1		
Race/Colour							
White	6	85.7	1	14.3	0.632	0.060 - 6.652	0.702
Non-white	38	90.5	4	9.5	1		
Social Class							
Middle/Low	26	89.7	3	10.3	0.963	0.146 - 6.358	0.969
Middle/Upper	18	90.0	2	10.0	1		
Tabagism							
Yes	13	86.7	2	13.3	0.629	0.094 - 4.217	0.633
No	31	91.2	3	8.8	1		
Alcohol Consumption							
Harmful/Dependency	4	80.0	1	20.0	0.4	0.036 - 4.500	0.458
Low Risk/Risk	40	89.8	4	10.2	1		

Source: created by authors. Race/Colour = White; Non-white (brown, black, indigenous). Middle/Low class = C, D, E. Middle/Upper class = A, B. *p-value < 0.05.

Table 3: Sedentary Behaviour and associated factors in students from Teresina - PI, 2019.

	Sedentary Behaviour						
	Yes		No		OR	CI: 95%	p-value
	n	%	n	%			
Age							
> 16 years old	13	56.5	10	43.5	2.311	0.724 - 7.375	0.157
≤ 16 years old	9	36.0	16	64.0	1		
Gender							
Female	11	36.7	19	63.3	0.368	0.111 - 1.228	0.104
Male	11	61.1	7	38.9	1		

Race/Colour							
White	4	57.1	3	42.9	1.704	0.337 - 8.601	0.519
Non-white	18	43.9	23	56.1	1		
Social Class							
Middle/Low	9	32.1	19	67.9	0.255	0.076 - 0.859	0.027*
Middle/Upper	13	65.0	7	35.0	1		
Tabagism							
Yes	7	50.0	7	50.0	1.267	0.364 - 4.409	0.71
No	15	44.1	19	55.9	1		
Alcohol Consumption							
Harmful/Dependency	1	20.0	4	80.0	0.262	0.027 - 2.539	0.248
Low Risk/Risk	21	48.8	22	51.2	1		

Source: created by authors. Race/Colour = White; Non-white (brown, black, indigenous). Middle/Low class = C, D, E. Middle/Upper class = A, B. *p-value < 0.05.

DISCUSSION

The main results showed that there are 89.8% of inactive adolescents, sedentary behaviour is exhibited in 45.8%, most adolescents (69.4%) do not smoke and they presented a low risk (89.8%) to alcoholic drink dependence.

The World Health Organisation (WHO) recommends that the population aged 5 to 17 years old should practice 60 minutes of moderate to intense physical activity per day, and three times per week to achieve health benefits, and with higher value and frequency, the benefits will be even greater (WHO, 2018a).

Physical inactivity is seen as an important factor in increasing financial costs in health, which directly impact economic planning (Bueno et al., 2016). 89.8% of the adolescents were inactive, different from the behaviour of the subjects of the Western Amazon region in which only 39.5% were inactive (Farias et al., 2019).
The ERICA study from 2014 showed that the Northeast region adolescents presented 55.7% of inactivity and 29.5% do not perform any physical activity per week, being the most frequent in this last classification. It is worth mentioning that females had the highest prevalence (Curreau et al., 2016).

In order to reduce physical inactivity by 10%, WHO member states developed goals by the year 2025, concerned about young people who represent the majority of insufficiently active population (WHO, 2018b).

Physical inactivity can also be a stimulating factor for alcoholic drinks consumption (Abreu et al., 2011). Alcohol consumption is something socially acceptable and frequent among teenagers that may occur in an abusive manner, leading to potential health risks. The results in this study do not differ from those observed in the Federal District students, where regular consumption of alcohol was affirmed by ¼ of adolescents (27.3%) (Malta et al., 2014). Adolescents consumed alcohol regularly in Feira de Santana-BA (28.1%) and Recife-PE (29.8%), according to a systematic review (Barbosa Filho et al., 2012).

Unlike the study in the Northeast Region which found an alcohol consumption high prevalence in the same age group in both genders, this frequency increased according to age, which suggests consumption maintenance over time, and it is worth highlighting the most consumed beverages were beer, vodka, rum, and tequila (Coutinho et al., 2016).

Malta et al. (2014) showed that regular alcohol consumption was higher among those who had already tried tobacco.

In a systematic review, it was found that among adolescents, alcohol and tobacco consumption has reached high prevalence in Brazil's several locations; in the Northeast Region, Feira de Santana-BA, tobacco was used by 61.5% adolescents aged between 14 and 19 years (Barbosa Filho et al., 2012).

In an inland town from Goiás, tobacco use was associated with the male gender, parents who smoke and having no religion, in which consumption increased according to age (Vargas et al., 2017).

This practice is more prevalent due to people closer to the family influence. Another influential aspect is belonging to unstructured families as with separate parents, and if the responsible person is an active smoker or has low income, this situation may worsen (Nogueira et al., 2012).

Alcohol consumption and tobacco use are less frequent in physically active adolescents (Malta et al., 2014). However, the time spent using screens is an increasing habit among adolescents; PeNSE showed that 79.5% of students in the ninth grade in elementary school showed such a behaviour which is above the recommended (Brazil, 2016).

The adolescents in this study presented 45.8% for sedentary behaviour, which is different from the study we already mentioned.

The ERICA study (2013-2014) showed that public schools students are less sedentary than those from private schools. The results corroborate this because one of the lowest frequencies (46.6%) is in the Northeast region for sedentary behaviour (Oliveira et al., 2016). However, the results are similar to those from Porto Velho-AM adolescents, in which 45% use screens > 2 (Farias et al., 2019). This habit is mainly due to the habit of having meals almost regularly in front of the TV (Oliveira et al., 2016).

Adolescents from the city of Nova Lima-BH were classified by a majority (59.3%) of lower middle class; additionally, in the survey conducted by Rajão et al. (2019), it was found that 80.2% have the family income lower than three minimum wages.

The results showed a negative association of lower middle social class who have a 75% reduced chance of presenting sedentary behaviour (95% CI: 0.076 - 0.859) in relation to upper middle class students; therefore, the lower middle class is a protective factor for sedentary behaviour.

As to it, the fact of having a lower income causes the promotion of active transport, such as the use of public transport, cycling and walking, besides performing domestic activities that cause greater energy expenditure for carrying out such activities (Knuth et al., 2011). Farias et al. (2019) found that lower middle class students mainly went to school by bus.

During adolescence, behaviour transmission, norms and values are influenced mainly by closer people, such as colleagues, caused by the instinct to develop autonomy and independence in this phase. Rica et al. (2018) found a similarity in the time of occurrence of leisure physical activity of upper middle class students to his/her parents, suggesting that parents' behaviour may influence their children to be more physically active (Rica et al., 2018).

Alves et al. (2012) found that activities are mainly aimed at leisure, in which soccer is the most sought after modality by both genders, in addition to popular games for girls.
Before sedentary behaviour results , it is necessary to create strategies aimed at promoting proper and healthy eating, and physical activity practicing, regardless of the volume and duration, can promote immediate effective impacts in reducing sedentary behaviour, in addition to providing healthy habits that can be consolidated during adult life (Oliveira et al., 2016).

These actions must be appropriate to everyone's reality, and the participation of everyone involved in school is essential (WHO, 2017) due to the behaviours of the closest people directly influencing adolescents' habits (Rica et al., 2018).

CONCLUSION

These study's findings indicated a high prevalence of physical inactivity and sedentary behaviour in adolescents of both genders, and regarding the associated factors, it was observed that the majority reported low tobacco use and low risk for harmful consumption of alcoholic beverages. An association of lower middle class with sedentary behaviour was found, suggesting that low-income people tend to spend less time using screens.
It is worth mentioning that the present study has limitations regarding the relatively small sample size.

However, research related to investigating the factors that influence adolescent physical inactivity in order to promote interventional actions to perform healthy practices in school are necessary.

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FAKTORI POVEZANI SA FIZIČKOM NEAKTIVNOSTI I SJEDILAČKIM PONAŠANJEM KOD STUDENATA

Cilj: Provjeriti učestalost fizičke neaktivnosti i sjedilačkog ponašanja te povezane faktore kod učenika. **Metode:** Transverzalna, analitička i studija zasnovana na školama. Uzorak je odabran zbog prikladnosti, a činilo ga je 50 učenika oba spola koji su upisani u redovni Srednjoškolski centar u gradu Teresina-PI. Razmatrane su sociodemografske i ekonomske varijable, nivo fizičke aktivnosti, sjedilačko ponašanje, pušenje i konzumacija alkohola. Deskriptivna statistika učestalosti, testovi povezanosti i neprilagođeni omjer izgleda su provedeni sa intervalom pouzdanosti od 95%. **Rezultati:** Učestalost fizičke neaktivnosti je bila 89,8%, a sjedilačkog ponašanja 45,8%. Utvrđena je negativna povezanost između srednje/niže društvene klase i sjedilačkog ponašanja; prema tome, učenici srednje/niže klase imaju 75% smanjenu šansu da ispolje sjedilačko ponašanje (95% CI: 0,076 - 0,859) u odnosu na srednju/višu klasu. **Zaključak:** Pronalasci studije su ukazali na visoku učestalost fizičke neaktivnosti i sjedilačkog ponašanja među učenicima oba spola, uz povezanost između srednje/niže klase i sjedilačkog ponašanja, a što ukazuje na to da osobe sa niskim primanjima imaju tendenciju da manje koriste uređaje se ekranima.

Ključne riječi: fizička aktivnost, sjedilačko ponašanje, studenti, adolescenti

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THE EFFECTS OF A MUSIC-DANCE WORKSHOP EDUCATIONAL PROGRAMME ON THE MOTOR ABILITY OF DEAF BOYS

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ABSTRACT

Deaf children are very often observed as children with difficulties in motor development even though they have a similar biological basis for their development which is the same as in hearing children. Through this research, we wanted to determine how much and what kind of influence do a music-rhythmic stimulation and movement have on the development of motor abilities of deaf children through an educational programme consisting of music-dance workshops in which we focus on the development of only one segment of motor ability - body coordination and movement speed. 12 deaf boys aged from six to ten took part in the programme which lasted four and a half months. At the beginning of the programme, we conducted an initial measurement of body coordination and speed of movement, and a final measurement after four and a half months of the programme through five standard tests: figure eight with bending (MKOS), side steps (MKKS), envelope test (MKKT), slalom with three medical balls (MKS3M), and backwards long jump (MKSUU). For the effects analysis of the applied music-rhythmic and dance stimulation, we used a t-test for final samples (paired samples test). The research results indicated certain statistically significant differences in the abilities of body coordination and movement speed, and that the music-dance workshops programme has a positive effect on the development of the selected motor abilities.

Keywords: motor ability, deaf children, music, dance, movement

INTRODUCTION

There is a general opinion that deaf children have a delayed development of motor abilities, and that they are not born with the same motor ability as hearing children (Rine et al., 2000; Schlumberger, Narbona, & Manrique, 2004). Research shows that a delayed motor ability in deaf children is at least or not at all connected with hearing loss, but that it is mostly connected with external factors such as active participation in physical activities (Kaltsatou, Fotiadou, Tsimaras, Kokaridas, & Sidiropoulou, 2013; Tzanetakos, Papastergiou, Vernadakis, & Antoniou, 2017). Because of this, hearing loss is considering as a sensor and communication invalidity rather than a physical one. The reason for this state of motor ability in deaf children is justified by their focus on auditory rehabilitation and speech development exercises, which is why physical stimulation, which is also very important for speech development, is neglected (Kaipa & Danser, 2016; Veiskarami & Roozbahani, 2020).

Physical education can contribute to rehabilitation, especially in the functional improvement of vestibular senses (Ita bleńKoWsKa; Rajendran, Roy, & Jeevanantham, 2012). The development of rhythm awareness mostly depends on whether the environment is stimulative enough for child development.

Deaf people can "hear" music; in fact, they can feel music through sound vibrations by means of touch sensors. In this process of sound perception, the skin and bones are the most involved, which are considered one of the best implements for sound vibrations. Sound and rhythm can be reproduced, but their proper reproduction depends on the level of motor ability. Therefore, motor abilities are one of the factors which are conditioning the correct reproduction of rhythm structure (Bengtsson et al., 2009; Grahn & Brett, 2007).

METHODS

The main goal of this research is to investigate the effects of music-rhythm and movement on motor abilities development of deaf boys aged 6-10. In this research, we used an intentional sample in which we choose those units which we considered as most typical for the population that we research and those which we considered as representative.

Considering that we used the case study method, the research sample comprises 12 deaf boys aged from 6 to 10, divided in two groups. In the first group, there are five boys aged 6 and 7, and the second group is comprised of boys aged 9 and 10.

Before implementing music-dance workshops, we conducted an initial measurement through motor ability assessment tests.

Five tests which are intended for measuring the body coordination ability simultaneously measure one more quality, and that is movement speed.

In order to determine the effects of music-rhythm stimulations and movement on the stated motor ability, we conducted a final measurement after four and a half months of the experimental programme.

The tests we used in this process are listed below: figure eight with bending (MKOS), side steps (MKKS), envelope test (MKKT), slalom with three medical balls (MKS3M), and backwards long jump (MKSUU).

The obtained results were processed through the statistical software program SPSS 21. Through this procedure, we used the central parameters of arithmetic mean (AM), standard deviation (SD) and standard error of arithmetic mean (SEM). For the effects analysis of the applied music-rhythmic and dance stimulations, we used a t-test for dependent variables (paired samples test). For this research, we created a special educational programme of music-dance workshops which lasted four and a half months.

The workshops were organised two times per week for the duration of 60 minutes.

The programme is created through three main phases which are intertwined and support each other.

The first phase is intended for the awareness of inner rhythm and the development of rhythmic reproduction with upper and lower extremities through exercises which are crated and adapted to sensory impairment.

The second phase in intended for dance education and the exercises rely on Laban movement analysis.

The third, end phase uses movement research through all space levels together with the development of rhythmic reproduction.

RESEARCH RESULTS

The conducted initial and final measurements of body coordination and movement speed should provide important results.

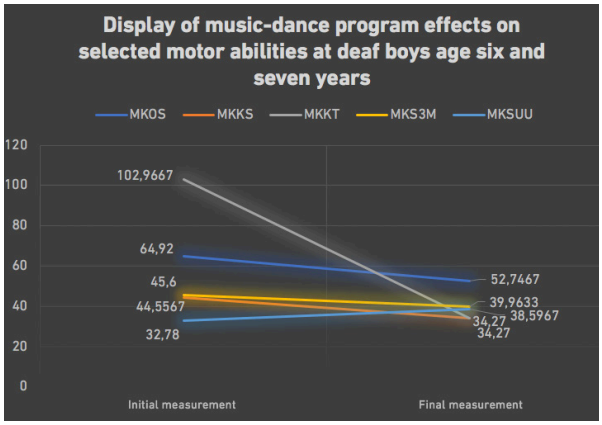
The selected motor abilities at the initial measurement where below age levels, which is on par with the previously mentioned research (Graph 1 and 2).

Graph 1 shows the difference between the initial and final measurements of deaf boys aged 6 and 7. The second graph shows the same testing procedure but in the other age group made up of deaf boys aged 9 and 10.

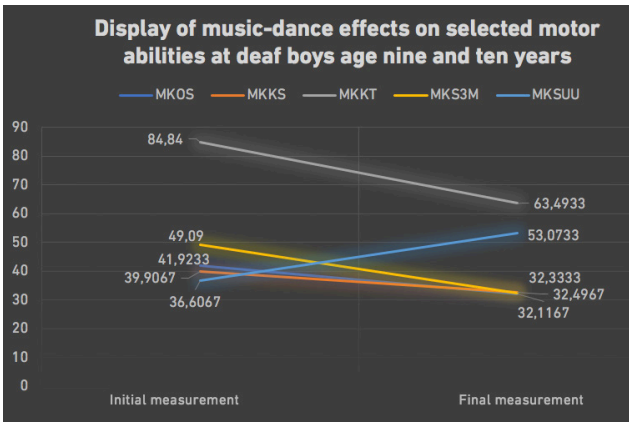
The analysis of the data shows us that the curves are in decline, except the curve which shows the test results for backwards long jump (MKSUU).

Since there has been improvement in movement speed, and thus in body coordination in both examinee groups, those curves are showing a decline.

The last test measures jump length, and as there was also an improvement in the performance of this test, in other words, the jump of these boys has been extended after the music-dance workshop, so this curve is showing growth.



Graph 1



Graph 2

In table 1, all the results show a significant difference at the level of significance $p < 0.05$, with the level of risk of 5%. The side steps (MKKS) test did not show a statistically significant difference in boys belonging to the group aged 6 and 7, which is $p = 0.109$, $t = 2.779$. The biggest statistically significant difference was found in the test MKKT ($p = 0.01$, $t = 39.770$) and followed by MKSUU ($p = 0.015$, $t = -7.991$), MKS3M ($p = 0.03$, $t = 17.212$) and MKOS ($p = 0.046$, $t = 4.513$).

Table 1: Paired Samples Test – selected motor abilities dependent variables of deaf boys aged 6 and 7

		Paired Differences			T	df	Sig. (2-tailed)
		AS	SD	SEM			
Pair 1	MKOS – MKOSF	12.17333	4.67163	2.69717	4.513	4	.046
Pair 2	MKKS – MKKSF	10.28667	6.41157	3.70172	2.779	4	.109
Pair 3	MKKT – MKKSF	68.69667	2.99183	1.72733	39.770	4	.001
Pair 4	MKS3M - MKS3MF	5.63667	.56722	.32748	17.212	4	.003
Pair 5	MKSUU – MKSUUF	-5.81667	1.26081	.72793	-7.991	4	.015

In table 2, all the results show a statistically significant difference at the level of significance $p < 0.05$ with the level of risk of 5%. The biggest statistically significant difference was found in MKKT ($p = 0.002$, $t = 24.562$) and followed by MKKS ($p = 0.003$, $t = 19.937$) and MKSUU ($p = 0.003$, $t = -18.246$), MKS3M ($p = 0.019$, $t = 7.181$), and MKOS ($p = 0.037$, $t = 5.022$).

Table 2: Paired Samples Test - selected motor abilities dependent variables of deaf boys aged 9 and 10

		Paired Differences			T	Df	Sig. (2-tailed)
		AS	SD	SEM			
Pair 1	MKOS – MKOSF	9.80667	3.38210	1.95266	5.022	6	.037
Pair 2	MKKS – MKKSF	7.41000	.64374	.37166	19.937	6	.003
Pair 3	MKKT – MKKTF	21.34667	1.50533	.86911	24.562	6	.002
Pair 4	MKS3M - MKS3MF	16.75667	4.04166	2.33345	7.181	6	.019
Pair 5	MKSUU – MKSUUF	-16.46667	1.56312	.90247	-18.246	6	.003

DISCUSSION

The results of this research show us that inclusion of deaf children is possible, and that there is no need to lower the criteria while creating an educational programme, but there is only a need to adjust the teaching methods to sensory impairments and, in that way, give the same possibilities to this population for professional art education and professional orientation. Dance is an inherent characteristic for deaf people because deaf people use their own body for communication in same way as professional dancers, so it is logical that deaf persons can dance with same quality or even with more expression than hearing people (Benari, 2014). Dance is an ideal activity for the development of motor abilities and self-awareness in deaf youth; it is a necessary tool which helps in self-actualisation, especially in awareness of their own body with the main goal being that those persons start to appreciate their own capability in movement performance (Fotiadou et al., 2006). An educational programme of a music-dance workshop which was specifically created for this research has a positive influence on body coordination and movement speed of deaf boys aged 6 and 7. Those results are at the same level as the results from other research (Gheysen, Loots, & Van Waelvelde, 2008; Peñeñory et al., 2016). The other group of boys, aged 9 and 10, showed some better results in the initial measurement in body coordination and movement speed, which was expected because of the fact that older children have more physical activity in school, compared to boys from the first age group. All the results of this research, which showed that music stimulations and dance have a positive impact on motor abilities of deaf children, are justifying the findings obtained from research in other scientific fields which deal with the impact of music and dance on motor abilities and which were used as a theoretical basis for this research (Arzoglou et al., 2013; Thaut, Trimarchi, & Parsons, 2014). In most cases, deafness causes the absence or degeneration of sensory cells, which breaks the connection between the peripheral and central nervous system (Gheysen et al., 2008; Niparko & Blankenhorn, 2003). Our research confirms that those results do not only refer to hearing people but also to deaf people, which confirms other research (Gheysen et al., 2008; Niparko & Blankenhorn, 2003), which shows that the auditory brain cortex receives sound vibrations which are coming through music stimulations. Through our research, we can assume that those vibrations which have a rhythmical structure travel to the motor cortex through which an improvement occurs in motor abilities (Smith, 2002), which emphasises the narrow connection between music and kinesiological intelligence and their mutual support. If we perceive all the specified findings from scientific fields which are represented in this paper, it clearly shows us that music has a great impact on motor abilities, but also on motor development in humans regardless of their hearing impairment. If we look at the wider picture, we can then assume that music and dance have a wider impact. By influencing the development of motor abilities, those two media also impact speech development, which is in direct connection with motor development (Hasanbegović, Mehmedinović, & Mahmutović, 2012), which has a great importance for deaf people.

CONCLUSION

The scientific cognition that arose from this research can be used in creating an educational process in the field of music and physical education with deaf children, but also in creating a special educational programme in music and dance schools as well as dance and sports clubs, which could include this population in their educational system.

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EFEKTI OBRAZOVNOG PROGRAMA MUZIČKO-PLESNIH RADIONICA NA MOTORIČKE SPOSOBNOSTI DJEČAKA S OŠTEĆENJEM SLUHA

Djeca sa oštećenjem sluha se često posmatraju kao djeca sa poteškoćama u motoričkom razvoju iako imaju sličnu biološku osnovu za razvoj koja je ista kao i kod djece koja čuju. Ovim istraživanjem smo željeli utvrditi koliki je i kakav uticaj muzičko-ritmičke stimulacije i pokreta na razvoj motoričkih sposobnosti djece sa oštećenjem sluha kroz obrazovni program koji se sastoji od muzičko-plesnih radionica u kojim se fokusiramo na razvoj samo jednog segmenta motoričkih sposobnosti - koordinacije tijela i brzine pokreta. 12 dječaka sa oštećenjem sluha u dobi od šest do deset godina je učestvovalo u programu koji je trajao četiri i po mjeseca. Na početku programa smo proveli inicijalno mjerenje koordinacije tijela i brzine pokreta, kao i završno mjerenje nakon četiri i po mjeseca programa kroz pet standardizovanih testova: osmica sa sagibanjem (MKOS), koraci u stranu (MKKS), koverta test (MKKT), slalom s tri medicinke (MKS3M) i skok u dalj unazad (MKSUU). Za analizu efekata primijenjenih muzičko-ritmičkih i plesnih stimulacija koristili smo t-test za završne uzorke (test za uparene uzorke). Rezultati istraživanja su ukazali na određene statistički značajne razlike u sposobnostima koordinacije tijela i brzine pokreta, kao i da program muzičko-plesnih radionica ima pozitivan efekat na razvoj odabranih motoričkih sposobnosti.

Ključne riječi: motorička sposobnost, djeca sa oštećenjem sluha, muzika, ples, kretanje

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CHANGE TRENDS IN PHYSICAL DEVELOPMENT OF ELEMENTARY SCHOOL CHILDREN

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ABSTRACT

Structural changes in body composition, which affect obesity problems, are one of the most common problems in modern society. Systematic monitoring of the complete anthropological status of children can prevent serious health problems in later life periods. The primary aim is to gain an insight into the "real situation" and to identify trends for changes related to physical development among children in order to re-establish and improve the monitoring system and make the current school curricula better. This research included a sample of 839 students which was extracted from the population of pupils from five elementary schools. An ANOVA linear regression analysis was used to analyse the tendency for changes in the observed indicators of physical development (height, weight and body mass index) in the function of age. The results of this study showed that the trend of change has a statistically significant increase in most of the monitored characteristics. In both genders, body mass index values are at the very upper limit of average values (for ages 7 and 10, BMI values are above average - at the 85th percentile), compared to the World Health Organisation reference values. It was determined that the analysed sample is characterised by the developmental stages with the highest growth peak among girls at the age of 10 (4.49% of change in BH, 16.32% of change in BW and 8.06% of change in BMI). Unlike girls, the results showed that the largest peak was the increase in body height of boys at the age of 14 (4.78%), body weight at the age of 13 (12.57%) and BMI at the age of 10 (6.19%). The results of the present study confirmed the need for effective interventions starting as early as infancy to reverse the anticipated trends. Monitoring of the trend of physical development among the youngest must be organised as a highly important continuous system of collecting information at the state level with the aim of determining the biological potential of the nation.

Keywords: 7–14-year-old children, body height, body weight, body mass index

INTRODUCTION

Today's living conditions are increasingly leading to a condition known as hypokinesia. This phenomenon inevitably leads to somatic changes of quantitative and qualitative nature and mostly affects the population of children in the characteristic sensitive periods of their development.

The phenomenon of hypokinesia, improper diet with consequent obesity and stressful urban lifestyle with a constant increase in nervous tension as well as physical and social exhaustion of the individual together cause the phenomenon defined as morbid triad- a triple syndrome that is the most common cause of illness and death (Vuori, 2004; Buscot, Thomson, Juonala, Sabin, Burgner, et al., 2018).

Health, in addition to the basic biological connotation of the absence of disease in a given individual, has other,

multidimensional benefits of the individual and society as a whole, such as the social, psychological and the already mentioned physical-work dimension. We can say that health represents the full ability to adequately and effectively overcome all the challenges imposed by everyday life and is basically a condition for the full realisation of the potential of each individual.

However, the indirect consequence of hypokinesia, through the adaptive biological mechanisms of the organism, causes the "modern man" to suffer more and more, primarily from the so-called non-communicable "modern age" diseases such as: obesity, diabetes, various cardiovascular disorders and diseases, osteoarthritic problems, etc. Unfortunately, these negative tendencies have been noticed among the younger population, and even in the population of school youth, as well as in Europe and America, and also in the Republic of Serbia (Gajević, 2009; Dopsaj et al., 2010; Ivanović & Gajević, 2016; Ivanović, Gajević, Parčina, 2020). Professional, scientific and public authorities' attention was increased in the previous years, so more and more experts were occupied around solving these problems - obesity, poor body posture and lack of physical activity.

Due to all of these facts, it is necessary to establish an intensive physical fitness and body composition monitoring system (de Onis, Onyango, Borghi, Siyam, & Pinol, 2006; Tambalis, Panagiotakos, Arnaoutis, Psarra, Maraki, et al., 2015; Ivanović & Gajević, 2016; Bićanin, Milenković, Radovanović, Gajević, & Ivanović, 2018). An essential tool for child growth monitoring contains data on body height and weight. They are a powerful "informational and monitoring tool" not only for child growth but also for the long-term health indication, especially in childhood and adolescence (Cattaneo, Monasta, Stamatakis, Lioret, Castetbon, et al., 2010; Wijnhoven, van Raaij, Spinelli, Rito, Hovengen, et al., 2013; Tambalis et al., 2015; Freedman & Berenson, 2017). Information about childhood obesity which is available in Serbia suggests that the prevalence of these factors has a trend similar to most of the European countries (Djordjic, Radisavljevic, Milanovic, Bozic, Grbic, et al., 2016) and anthropometric variables related to this area indices are increasing during the last 10 years (Gajević, 2009; Ivanović & Gajević, 2016).

Besides these facts, the results of the previous study confirmed this troubling prevalence in our country, indicating a secular trend of increasing among pre-school children (Ivanović et al., 2020). Structural changes in body composition, which affect obesity problems, are one of the most common problems in modern society. Obesity is a serious public health problem in almost all countries in the world. An additional problem is the fact that this chronic non-communicable disease is increasingly affecting children. Systematic monitoring of the complete anthropological status of children can prevent serious health problems in later life periods. Based on the results of many previous research, the ideal period for intervention should ideally commence when the children are six years old. High BMI values start in adolescence for males and early adulthood for females, suggesting a critical window for secondary prevention (Buscot et al., 2018).

Precisely because of all that, as well as on the basis of the results of previous research, it is considered and can be concluded that research in the coming periods should be more based on monitoring, control and analysis of physical development of primary school children. The primary aim, based on a conducted pilot survey of school-age children in Belgrade, is to gain an insight into the "real situation" and to identify trends for changes related to physical development among children in order to re-establish and improve the monitoring system and make the current school curricula better.

MATERIALS AND METHODS

Participants

This research included a sample which was extracted from the population of pupils from five elementary schools. The total sample of examinees was 839 students (424 boys and 415 girls). Thus defined, the sample was distributed among eight subsamples, both in boys and girls. The criteria for the distribution of subsamples were years of age, with rounding to ±6 months, which provided the following subsamples in both genders: 7, 8, 9, 10, 11, 12, 13, and 14 years. The parent of each subject was informed about the potential risks and discomfort associated with the investigation, and measurements were carried out upon obtaining the willing consent of their parents in accordance with the requirements of the Declaration of Helsinki.

Procedures

Body weight (kg) was measured to the nearest 0.1 kilogram with a calibrated scale over time (Seca, Germany), according to international standards for anthropometric assessment, in a private setting, during the morning hours, with students being dressed in light clothing. Body mass index (BMI) was mathematically estimated according to the equation BMI = weight/height2 (kg/m^2). Standing height (cm) was measured in the standing position with a portable stadiometer (Seca®, Hamburg, Germany).

Statistical analysis

All the results were processed with the application of descriptive statistics, and the tendency for changes in the observed characteristics in the function of age was subsequently defined by applying the linear regression method, using the general equation: y = abx. All statistical methods

were processed in the SPSS software package for Windows, Release 20.0 (Copyright © SPSS Inc., 1989-2011).

RESULTS

Table 1 shows the results of the ANOVA linear regression analysis at the partial level in all the observed indicators of physical development of both genders.

Table 1: The results of the ANOVA linear regression analysis

	female		male	
	t-value	p	t-value	p
Body height (cm)	2.493	0.013	6.280	0.000
Body weight (kg)	2.685	0.008	-0.218	0.828
Body mass index (kg/m²)	-2.290	0.023	0.979	0.328

Graphs 1-3 show the results of the defined functions of the linear regression equation for body height, body weight and body mass index in both genders.

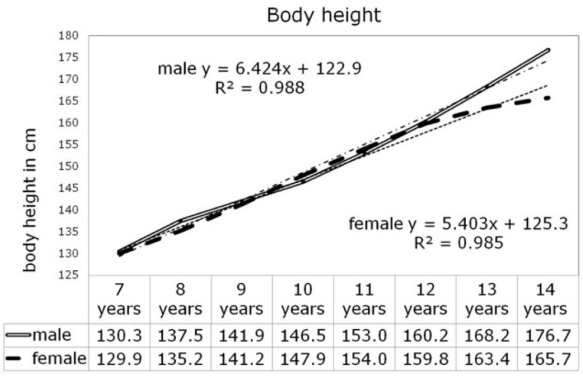

Figure 1: Change trends of the body height

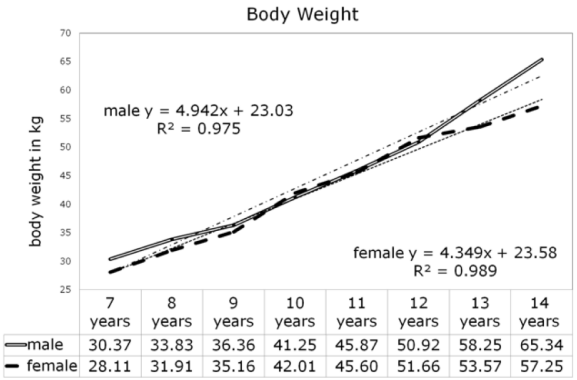

Figure 2: Change trends of the body weight

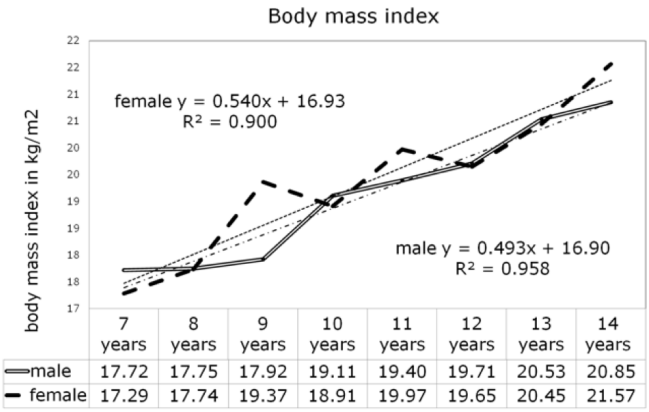

Figure 3: Change trends of the BMI

The defined linear regression equations have the following form for:
- the basic measure of longitudinality - body height, in boys - y = 6.424x + 122.0 with an assessment reliability of 98.87% (R^2 = 0.9887); in girls - y = 5.403x + 125.3 with an assessment reliability of 98.58% (R^2 = 0.9858);
- the basic measure of voluminousness - body weight, in boys - y = 4.942x + 23.03 with an assessment reliability of 97.53% (R^2 = 0.9753); in girls - y = 4.349x + 23.58 with an assessment reliability of 98.90% (R^2 = 0.9890);
- the basic measure in assessing the physical status, i.e., nutritional status - body mass index, in boys y = 0.493x + 16.90 with an assessment reliability of 95.84% (R^2 = 0.9584); in girls – y = 0.616x + 16.04 with an assessment reliability of 95.53% (R^2 = 0.9553).

DISCUSSION

The results of this study showed that the trend of change has a statistically significant increase in most of the monitored characteristics (Table 1):

- body height - 6.62 and 5.11 cm annually in relation to the time period of eight years, at the level of significance p = 0.000 in boys and p = 0.013 in girls, respectively,
- body weight - 5.00 and 4.16 kg per year in relation to the time period of eight years, at the level of significance p = 0.828 in boys and p = 0.008 in girls, respectively,
- body mass index - 0.45 and 0.62 kg/m2 annually in relation to the time period of eight years, at the level of significance p = 0.047 in boys and p = 0.023 in girls, respectively.

The results of all examined indicators for the assessment of physical development show that the average higher values were measured in male subjects (except in the age categories of the fourth and sixth grade) (Figure 1-3).

The largest average differences in the observed indicators were measured in eighth grade students,

where boys had a surplus of 6.88%, compared to girls. In both genders, BMI values are at the very upper limit of average values (for ages 7 and 10, BMI values are above average - at the 85th percentile), compared to the World Health Organisation reference values (www.who.int/toolkits/child-growth-standards). Childhood overweight and obesity have dramatically increased since 1990. Based on the results of the investigation conducted by de Onis (2010), it was concluded that in 2010, 43 million children (35 million in developing countries) were estimated to be overweight and obese; 92 million were at risk of overweight. Besides, the worldwide prevalence of childhood overweight and obesity increased from 4.2% in 1990 to 6.7% in 2010. This trend is expected to reach 9.1%, or 60 million, in 2020 (de Onis, Blössner & Borghi, 2010).

In relation to the trend of changes in the monitored characteristics, it was determined that the analysed sample is characterised by the developmental stages with the highest growth peak among girls at the age of 10 (4.49% change in BH, 16.32% change in BW and 8.06% change in BMI). Unlike girls, the largest peak growth in boys differs significantly. The results showed that the largest peak was the increase in body height of boys at the age of 14 (4.78%), body weight at the age of 13 (12.57%) and BMI at the age of 10 (6.19%).
Comparing the obtained data with the results of previous research (Gajević 2009), it can be concluded that there is a significant changing tendency of the observed characteristics of physical development in primary school students measured in 2014, compared to the sample of girls and boys measured in 2009, by the same methodology and in the same area.
At the general level, among girls, there is a tendency to change the monitored characteristics in relation to the sample of girls measured in 2009. At this point, the given tendency can be quantified by the following values of the direction and intensity of change:
- Body height was changing with a trend of 0.27 cm of decrease, compared to the observed stratum from 2009,
- Body weight was changing with a trend of 0.10 kg of decrease, compared to the observed stratum from 2009,
- BMI was changing with a trend of 0.07 kg/m2 of increase, compared to the observed stratum from 2009.
Unlike girls at the general level, in boys there is a tendency that can be quantified by the following values of direction and intensity of changes:
- Body height was changing with a trend of 0.48 cm of increase, compared to the observed stratum from 2009,
- Body weight was changing with a trend of 0.07 kg of decrease, compared to the observed stratum from 2009,
- BMI was changing with a trend of 0.16 kg/m2 of decrease compared to the observed stratum from 2009.
Based on these indicators, it is not difficult to conclude that there have been significant constitutional changes in primary school children in the last decade. These results are not surprising because the data obtained by the study of Gajević (2009) unequivocally showed that primary school children are higher than in 1995 (for ages 7 to 14, body height increased by an average of 3% in boys and 2.5% in girls). At the same time, for the same period, the body weight of primary school children increased by an average of 14% among boys and 11% among girls. Body mass index values increased on average by 7.3% in boys and 5.6% in girls. In addition, the results of the same research showed that, compared to the results of primary school children from other European countries, primary school students in the Republic of Serbia recorded an above average level of the results related to all three variables that mark physical development, in both genders. Similar results were published by Strel (2009). Namely, the results of extensive research in Slovenia, "Longitudinal comparison of development of certain physical characteristics and motor abilities of two generations of children and youth, aged 7 to 18, in Slovenian primary and secondary schools in the period 1990-2001 and 1997-2008" (Strel et al., 2009), showed that the body weight of students increased to 4% and the amount of subcutaneous adipose tissue to 13%. On the other side, in the United States, for example, 17% of youth aged 2 to 19 years old are obese, although the prevalence remained stable between 2003-2004 and 2009-2010 (Ogden, Flegal, Carroll, Johnson, 2002; Ogden, Carroll, Kit, & Flegal 2014). The rates are generally higher in girls than in boys (Cattaneo et al., 2010).

CONCLUSION

This study provides current information on change trends of somatic growth in children of elementary school age. The results of the present study confirm the need for effective interventions starting as early as infancy to reverse anticipated trends.
Monitoring of the trend of physical development among the youngest must be organised as a highly important continuous system of collecting information at the state level with the aim of determining the biological potential of the nation. This becomes even more important with the appearance of a pandemic, increasing the prevalence of obesity which is related to young people, declining their levels of physical abilities and increasing the frequency of non-communicable diseases.

Through a proper evaluation of the results which was analysed in this study, it is possible to obtain very informative data for the purpose of managing and monitoring the school children's anthropological status, but also for the Serbian National Measurement System improvement.
The results can also be utilised for the normative data at the national level, as well as a model for the comparison with morphological and fitness characteristics of children from the other European countries.

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TRENDOVI PROMJENA U FIZIČKOM RAZVOJU DJECE OSNOVNOŠKOLSKOG UZRASTA

Strukturne promjene u tjelesnoj građi, koje utiču na probleme sa pretilosti, su jedan on najčešćih problema u modernom društvu. Sistematičko praćenje cjelokupnog antropološkog statusa djece može spriječiti ozbiljne zdravstvene probleme koji nastaju u kasnijim periodima života. Osnovni cilj je dobiti uvid u "stvarnu situaciju" te identifikovati trendove promjena povezanih sa fizičkim razvojem djece kako bi se ponovno uspostavio i poboljšao sistem praćenja i unaprijedili trenutni nastavni planovi i programi. Ovo istraživanje je obuhvatilo uzorak od 839 učenika koji su odabrani iz populacije učenika pet osnovnih škola. ANOVA linearna regresijska analiza je korištena za analizu sklonosti ka promjenama u posmatranim indikatorima fizičkog razvoja (visina, težina i indeks tjelesne mase) u funkciji dobi. Rezultati ove studije su pokazali da je trend promjene imao statistički značajno povećanje u većini praćenih karakteristika. Kod oba spola, vrijednosti indeksa tjelesne mase su na samoj gornjoj granici prosječnih vrijednosti (za dob od 7 do 10 godina, BMI vrijednosti su iznad prosjeka - na 85. postotku) u poređenju sa referentnim vrijednostima Svjetske zdravstvene organizacije. Ustanovljeno je da se analizirani uzorak odlikuje razvojnim fazama uz maksimalan rast kod djevojčica u dobi od 10 godina (4,49% promjene u TV, 16,32% promjene u TM i 8,06% promjene u BMI-ju). Za razliku od djevojčica, rezultati su pokazali da je maksimum povećanje tjelesne visine dječaka u dobi od 14 godina (4,78%), tjelesne težine u dobi od 13 godina (12,57%) i BMI-ja u dobi od 10 godina (6,19%). Rezultati trenutne studije su potvrdili potrebu za efektivnim intervencijama počevši već od ranog djetinjstva kako bi se preokrenuli očekivani trendovi. Praćenje trenda fizičkog razvoja kod najmlađih mora biti organizovano kao iznimno važan neprekidan sistem prikupljanja informacija na državnom nivou sa ciljem utvrđivanja biološkog potencijala nacije.

Ključne riječi: djeca u dobi od 7 do 14 godina, tjelesna visina, tjelesna težina, indeks tjelesne mase

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BUSINESS CONTINUITY MANAGEMENT (BCM) IN SPORTS ORGANISATIONS AND THE COVID-19 PANDEMIC

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ABSTRACT

On the 11th March 2020, the World Health Organisation declared the global pandemic caused by the SARS-CoV-2 virus. Described as a COVID-19 global crisis, it has been primarily defined as a long-term health crisis of the entire mankind. Nowadays, these consequences are visible and strongly reflected in most aspects of modern life - the economy, social functioning, security, etc. The consequences are visible in the sports area as well. The world community faced a specific security crisis that represents a real danger for the survival and functioning of all subjects in both social and business interactions. The effects of post pandemic measures that the government adopted to fight COVID-19 generated different negative consequences. They are also reflected on the functioning of sports organisations. As the places intended for the organisation of physical exercise, almost all sports subjects had a specific management "stress" with the dominant emphasis placed on the discontinuity of the organisational process. This situation was dramatic, considering the fact that it came from the external environment, suddenly and without any previous indication about its length or intensity. One of the possible answers of the sports organisation's managing structures in this business environment is more intense study and the application of the Business Continuity Management concept. The realisation of BCM is based on adequate activity planning and measures that need to be applied so that the crisis situation would not disturb the set coordinates of the business process in the sports organisation. The goal of this theoretical study is aimed at the analysis and explication of the determinants of the BCM concepts as well as the recognition of the possible applicability in the sports organisation's managing activities.

Keywords: sports organisation, business continuity, pandemics, COVID-19

INTRODUCTION

The development of the civilisation was accompanied by different events that had one constant, and this was the change. Their level, intensity and wholeness were conditioned by different aspects, and one of the factors of the civilisation change were crises. The modern human society has the characteristics of fast-paced changes that were predominantly conditioned by technological advancements. Having in mind the etymology of this notion (Greek xoiois; Latin crisis), the core idea is the interruption of a continuous/normal development. In this sense, the common variants of every crisis are: a threat, a surprise, time pressure, stress, the initiation of far-reaching changes, etc. (Coombs, 2010; Neujahr & Wienand, 2010). Therefore, the basic characteristic of every crisis is discontinuity. In this sense, the modern management science created an application area - the crisis management - as a concept that helps organisations "fight" the crisis. This mainly represents the readiness of the managing structures to

make proper decisions in crisis situations that enable the development of the organisational ability to react quickly, efficiently and effectively in non-standard circumstances. This organisational ability (Lentzos & Rose, 2009) has the goal to minimise threats that are aimed at the health of human resources as well as the security (individual and/or organisational), lowering the bad consequences of the crisis (on the public or organisation property) as well as decreasing the negative influences on business continuation (normal organisational dynamics).

The latest global crisis, that was announced as a pandemics and named COVID-19, is caused by the SARS-CoV-2 virus. The World Health Organisation announced it on the 11th March 2020 (WHO, 2020) and defined it as a major health threat to the entire mankind. Although its orientation is dominantly reflected in the context of health, it strongly influenced other aspects of modern life (the economy, social functioning and sport). In this sense, we can say that the world community faced a specific security crisis that represents a real danger for the survival and functioning of almost all subjects in social and business interactions (Đukić, 2020).

The specificity of sports organisations' functioning lies in the fact that the success of the business outcome is based on the process of continuity. This is especially reflected in the central part of the sports system - the training process. The discontinuity of planned activities drastically reduces the effectiveness of the transformation process which is the basis of creating sports results. As a consequence, the business success of the sports organisation is connected to this process. The effects and consequences of the post pandemic measures, which the authorities adopted in the fight against the COVID-19 crisis, are negatively reflected on the work of sports organisations as places intended for the organisational articulation of physical exercise. Almost all sports subjects experienced a specific management stress that was predominantly reflected on the discontinuity of the major part of the organisational process. This generated negative contexts in the central part of the system - the training process (Dragić, Kastratović, & Ahmić, 2020). This situation was experienced as dramatic, considering the fact that it came from the external environment, suddenly and without any previous warnings about its length or intensity. The managing structures of the largest number of sports organisations were not ready for such a radical change of business conditions, and one of the reasons of inner disharmony (especially in the first months of the pandemics) was connected to the lack of knowledge about the principles and tools necessary to take in the process of crisis management (Nešić, Srdić, & Nešić, 2021).

The breaks in the business process in every organisation (sports organisations as well) can cause different types of losses. Firstly, the financial loss, but also other types (the loss of clients, decreasing the products' demand and/or services, technological delays/losses, lowering the sports results, etc.) that can be expressed through financial parameters. Lastly, this can be easily recognised through financial parameters. In certain periods of the crisis, losses can be relatively invisible or neglectable, but in another moment, they become very observable and measurable. In today's competitive business society/market, the interruption of the usual business activities, regardless of the time dimension, can lead to the fall of the organisation's value (Samantha, 2018). In organisations which are primarily focused on service distribution (just like sports organisations), the loss of reputation and/or interests for their services from the clients/users is one of the most dangerous long-term consequences of the business (activity) discontinuity. The financial losses that are caused in this way are not entirely visible, but can have a significant influence on the business "crash" of the (sports) organisation.

In this context, the goal of this short study is the analysis and explication of the basic parameters of business continuity management, as well as the possibility of its application in the sports organisation management process.

DETERMINANTS OF THE BCM CONCEPTS

Business Continuity Management has only recently become the notion of interest in the managing structures of Serbian companies, but also in the entire region (ex YU). One of the reasons why it was noticed is that business organisation continuity is a model of successful business management in the competitive and unstable business environment.

Therefore, the managers on higher positions have to understand the basic parameters that determine the effective and efficient continuity of the business process, which means the BCM determinants. In this way, the starting positions for the evaluation and improvement of business organisation performance have more results. In this way, they enable the conditions for improving their activities.

Studying the BCM concepts, up to now, was predominantly focused on the recovery of the organisation from an active crisis situation (catastrophes caused by fire, flood, IT sector malfunctions, etc.). However, the concept is applicable in almost all forms of crisis situations (e.g. business scams, main supplier problems, problems with buyers/users, etc.) as well as in the context of an actual pandemic (and all its direct and indirect consequences).

The management's understanding of BCM should be based on the fact that it is a process (it should be proactive) and the only thing that cannot be 'bought'. You can buy certain tools, techniques, guidelines, etc. that can be useful, but in the final form of BCM, the management activity has to be conceptualised as a correlation of the business concept that is conditioned by the crisis situation (Hecht, 2002).

The BCM concept represents the dynamic, proactive and continuous process that requires constant updating as well as adjusting to the real situation in the organisational environment. Only on this principle, their purpose, effectiveness and efficiency can be ensured. To be coherent with the principles of the BCM strategy means: securing employees and/or members security, the defence of the reputation or brand of the organisation, minimising the influence of the crisis event/ incident on clients, protection of the property and key resources of the organisation, etc. (Reuvid, 2005).

One of the approaches to the BCM concept (that the Institute of the Business Continuity from Great Britain uses) is the predictability of incidents that can influence the key functions and the organisational process, and an adequate (planned and rehearsed) management response/reaction to any incident (Gallagher, 2003). In this sense, there are three elements: (1) prediction of the crisis event/incident[1] (management should write the potential risks/threats that the organisation can have and predict all the activities that can be done in case of their activation); (2) identification of the critical elements that directly influence the organisational functions and processes (that are not part of the regular business problems; BCM is focused on the incidents that are not typically present in the life of the organisation, and whose occurrence can cause problems for the organisational process and the dynamics); and (3) creating plans for an adequate crisis response.

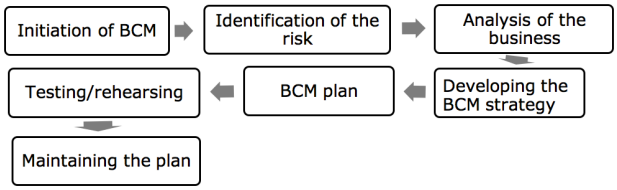
In this case, the standardised BCM methodology (British Standard Institute – BSI; BS 25999-1/2016) concluded that business management continuity is the holistic management approach where potential threats towards the organisation are identified in addition to their influence on business. The BCM system gives the framework for building the organisation's resilience that enables the efficient response towards the threats and protects the interests of the stakeholders (Hiles, 2007).

As a management concept, BCM implicitly has a wider context and range of business crisis management and recovery from the consequences. In this sense, business management continuity should not only be viewed as a process of recovery from incidents, prevention and/or the decrease of the effects caused by the problematic events on business operations functioning, but also as a managing activity that unifies a wide spectrum of business disciplines (risk management, knowledge management, the security system, crisis communication, managing objects, etc.).

The main BCM principle is the responsibility for the continuation of the business organisation during and after the crisis event. The responsibility falls on the top management (and the head of the company) responsible for the conditions (efficient decisions) necessary for the continuation of the business processes and operations (Woodman, 2007). In this sense, BCM represents a holistic management concept (process) that is able to identify potential threats to an organisation and its processes. The application of the BCM concepts enables the creation of an organisational resilience framework that can create the conditions for an efficient crisis response (the protection of the organisation's interests, stakeholders, business reputation, the brand, etc.).

BCM is closely connected to the risks that are seen as a potential business organisation danger and that are written down in its crisis portfolio. In this context, developing the concepts of BCM elements should be based on several managing questions (Doughty, 2001): (a) is the management satisfied with the organisational activities (plans) for managing organisational risks? (b) does the organisation have an adequately structured concept of BCM that corresponds to the environment and the concrete risks? (c) does the management have clear coordinates that provide the basis for the decisions that would make the organisation less vulnerable in comparison to the other competition in the crisis situation? (d) are there specific plans for requiring a secure contact and continuation of the business with the crucial stakeholders?

The main phases of the BCM process are (Fulmer, 2004): (a) initiation of the BCM project, (b) identification of the risk, (c) analysis of the influence on business, (d) developing the BCM strategy, (e) making plans for business continuity (BCP), (f) testing the plan/ rehearsing, (g) maintaining the plan (Picture 1).



Picture 1: BCM process phases
Source: Fulmer, 2004; adjusted: by authors

[1] In the context of the BCM concepts, it is necessary to use the term incident, not disaster. Disaster is primarily focused on natural disasters (fire, flood, explosions, etc.), while the incident includes other problematic events that can change the organisational dynamics and business continuity (frauds, product contamination, brand counterfeit, incomplete service, malfunctioning of the IT systems, political insinuations; in sport: fixing of the sports results, use of uncertified devices and equipment; disregarding sport rules in the context of security equipment and/or preventive measures on the sports fields, etc.).

APPLICATION OF THE BCM CONCEPTS IN THE SPORTS ORGANISATION

By observing them from the BCM perspective, sports organisations represent a specific organisational system whose central part is the training/exercise process, although the structural functioning of the sports organisation is characterised by the existence of more interrelated subsystems (the training process, selection, management, marketing, sports objects, infrastructure, finances, etc.). The specificity of the managing dynamics is the obligation of the managing structures who have to enable all the conditions for permanent functioning of the training process (Nešić, 2014). Its main business characteristics are related to the process continuity.

This is because of the fact that the basic characteristics of sports training are reflected in the application of the dosed stress (which has the purpose of activating the adaptive mechanisms in the athlete's organism). This process has to be adequately planned, controlled, and efficiently executed.

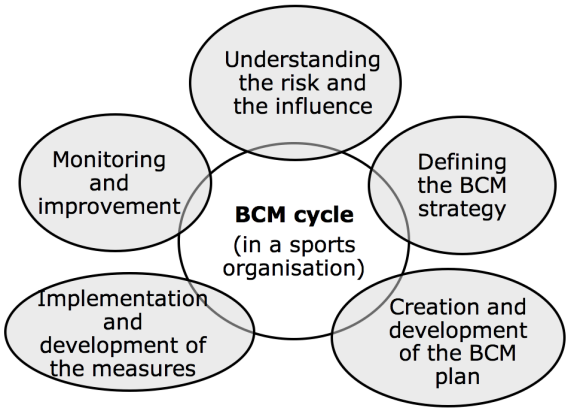
The main tool in the training process is physical exercise that has the aim to be implemented among athletes depending on the desired training goals. Sports training, as the basis of the sports organisation business, should be observed as a specific long-term and intense process of organism adaptation by applying optimal training stimuli (tools, methods) in the planned time.

Its goal is the transformation of the anthropological characteristics which are dependent on the achievement of the planned sports results (Fratrić, 2006).

In order to reach these determinants, the organisation of the training process (physical exercise, regardless of the level of sports aspirations) should be based on the principles of continuous work. In this managing segment of sports organisations, the pandemic or the crisis, which is characterised by the duration (more than a year) and its global nature, influenced the appearance of discontinuity in almost all sports systems.

This did not only happen in the training process and the space of sports competitions (reflections of the quality and efficiency of the training process), but also in other parts of the sports organisation system (management, business performance, logistics, etc.) (Nešić, 2020).

It is about the source of the crisis that dominantly comes from the external environment (Noth & Rehbein, 2019), but with its characteristics and the intensity, directly influences the processes inside the (sports) organisation. In order to conduct activities more efficiently, as a response to the crisis situation, and apply the BCM elements, the managing structures of the sports organisation can form crisis teams. They should be characterised as flexible and dynamic structures (the members of the team are grouped in accordance with the specific problem that is generated by the concrete crisis situation). The crisis team of the sports organisation needs to be focused on suggesting the activities and arranging the resources that are necessary for BCM. In this sense, BCM can be treated as a cyclical process of the exchange of information inside the sports organisation (as a whole, but also inside the managing structures or the managing teams in specific subsystems of the sports organisation) about the risks and the assessment of their influence (Picture 2). Based on these pieces of information, the appropriate strategies and the ways of implementation are suggested by the team (as an activity of the crisis response). In this way, the conditions for a more efficient recovery process of the BCM performance are created. Furthermore, this enables the appropriate (necessary) coordination among the connected stakeholders (Baba, Watanabe, Nagaishi, & Matsumoto, 2014).



Picture 2: Bthe extent of the BCM cycle as an activity basis of the crisis management in the sports organisation
Source: Baba et al., 2014: 298; adjusted: authors

The application of the BCM model has the crisis team as a central operational subject of the sports organisation in the crisis period (crisis response). It is possible to observe it through its role in defining the extent of the crucial internal-external factors that are necessary for the adequate response in the crisis situation and the realisation of business continuity.

This is primarily related to the identification of the processes that can appear inside the sports organisation as relatively independent activities

(controlling human resources, the club infrastructure, finances, knowledge/training technology, information, etc.) but are in the direct function of the basic sports organisation functioning (training) (Table 1).

Table 1: Sports organisation resources necessary for the functioning of the BCM project

Resources	Environment	
	Internal	**External**
Human resources	- members of the managing boards - sports organisation's employees - non-athlete members - athlete members	- representatives of the association - representatives of the territorial sports associations - representatives of the government in the area of sport - volunteers/friends of the club - academic institutions
Infrastructural	- sport facilities - sports equipment (owned by the club or personal) - technological equipment - technical equipment and appliances	- energy sources needed for the functioning of the sport infrastructure (gas, electricity, telecommunications, etc.) - water (supply, maintaining hygiene, etc.) - available community infrastructure (roads, the railway, airport, etc.)
Financial	- estate and financial means (money) - the accounting system of the club - contracts - insurance, etc.	- public finances - the local community's budget - banking/credit funds - sponsors and donations
Information	- the organisation's archive - training process plans - data on athlete testing - data on the functioning of the sports organisation - business documents - organisational knowledge/training technologies - the internal database, etc.	- the Internet - telephone installations and appliances - the public communication system - the database of sports associations - the database of the state sports institutions

The realisation of the BCM concepts is based on adequate planning of activities and measures that are necessary so that the crisis situation would not damage the coordinates of the business process in the sports organisation. In this sense, the integral part of BCM is the business continuity planning system (known as BCP) that is immanent in the context of sports organisations.

During business continuity planning, it is necessary to answer several questions that guide the course of the activities:

(a) who has a leading role in the sports organisation in defining the goals, policies and key factors of business success in the crisis situation; (b) who coordinates BCP activities in the (sports) organisation; (c) what are the methods of control and who is in charge of supervising the changes that are created during the period of implementing BCM projects; (d) presenting the members' plan of the (sports) organisation, who are fulfilling the planned tasks; (e) who should be additionally included in the creation of the budget project for BCM in the crisis situation; (f) determining the hierarchical structure of responsibility in the organisational dynamics before, during and after the realisation of the BCM project.

BCP is based on four steps that the managers-planners should apply (Baba et al., 2103): (1) the analysis of the danger, risk and vulnerability of the organisational process, (2) the evaluation of the organisational infrastructure and availability of the resources, (3) the analysis of the risk scenarios and the influence on the business, and (4) the formulation of the plan.

In the formulation of BCP and its implementation, the BCM project of the sports organisation should start from the following elements (Baba et al., 2014): 1) the analysis of the environment (understanding), 2) designing (defining strategies), 3) the creation and development of the plan, 4) implementation (action) and 5) evaluation (monitoring) (Table 2).

Table 2: Steps for the formulation of BCP and implementation of the BCM concept

Basic problem questions		**BCP**	**BCM**	
Analysis (understanding)	***Defining strategies***	***Development of the plan***	***Implementation (action)***	***Evaluation (monitoring)***
▪ organisation's stakeholders ▪ understanding the reality of the environment ▪ the analysis of the external threats and risks ▪ the analysis of the organisational infrastructure and the available resources	▪ differentiating the BCP-BCM relation ▪ preparing the risk scenario ▪ the analysis of the risk impact on business ▪ problems for the business environment continuity	▪ the analysis of the management ▪ BCP direction: ▪ protection of the endangered infrastructure ▪ protection of the endangered resources ▪ readily answer to the crisis/incident ▪ recovery, cooperation in the chain of services, etc.	▪ the activation of BCP ▪ risk reduction measures ▪ readiness and efficiency of reaction ▪ simulation and rehearsal/training ▪ alternative coordination measures	▪ counselling ▪ the evaluation of the activities and effects ▪ information analysis for improving plans

CONCLUSION

The global crisis caused by the COVID-19 pandemic represents the type of the external factor that shows a direct influence on the destabilisation of business activities in organisations. Besides the dominant health risk that is connected to the human resources and, consequently, its (dis)functioning in the organisational system framework, the negative consequences that affected the entire business (economic) activity of the organisation were no less dangerous. In this context, sports organisations can also be included. Considering the fact that the COVID-19 pandemic is still active, in order to grasp its complete consequences on the entire industry and social system of the state, it is necessary to wait for it to finish. But even now, certain activities can be analysed and recognised. In this way, there are responses towards the negative influence on business (sports) organisations. In the case of theoretical and practical management, the BCM concept brings more attention as a possible response inside the organisational system to the negative pandemic inputs that come from the external environment.Organisational dynamics of every business system (sports system as well) is determined by the influence of three basic factors: (a) organisational behaviour, (b) organisational specificities and (c) the characteristics of the external environment. In the context of our study, the attention of the sports organisation managing structures should be focused more intensely on external factors as the sources of crisis (the so-called environmental factors of the possible destabilisation of the business processes). The destabilisation of the external environment, that was created at the beginning of the pandemic in 2020 and is still active, is manifested in the discontinuity of the business activities of sports organisations (to a smaller or greater extent) in several ways: (1) the disruption of the activity dynamics in the relation with the external stakeholders (suppliers), (2) decreasing and/or a complete collapse of the activities in a certain time span due to the restriction measures imposed by the government organs, (3) changing the habits and needs of the sports organisation clients/users (that can have a negative effect on the liquidation of the organisation), (4) restricting people's mobility (decreasing contact, and in this way, there is a severe reduction of the sports competitions as places of sports system verification), (5) international restrictions (the impossibility of crossing the border) that can have negative consequences on business competitiveness (and the survival of the organisations), etc. The COVID-19 pandemics and its influence on business subjects showed primary focus on the reactive management in managing sports organisations. This became visible in the answers to the crisis input, where the concept of relative "sacrifice" of the business efficacy could be noticed.

This was seen through the reduction and/or diversification of the activities in order to keep specific effectiveness (fulfil previously defined long-term goals).

An intense application of the tools and methods of the BCM concepts is one of the possible management solutions to the observable negative trends. This could make the future business of the sports institutions more acceptable to the situation of the external environment. Of course, there should be encouragement from the academic part of kinesiological science to actively participate in finding the answers for sports functioning in the crisis periods. This study is one small step in this direction.

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UPRAVLJANJE KONTINUITETOM POSLOVANJA (BCM) U SPORTSKIM ORGANIZACIJAMA I PANDEMIJA COVID-19

Svjetska zdravstvena organizacija je 11. marta 2020. godine proglasila globalnu pandemiju izazvanu virusom SARS-CoV-2. Sada već identifikovana kao COVID-19 globalna kriza, pozicionirala se u obliku velike dugoročne zdravstvene prijetnje po cjelokupno ljudsko društvo. Međutim, danas se njene posljedice vidljivo i snažno reflektuju na sve druge aspekte savremenog života - ekonomiju, društveno funkcionisanje, bezbjednost, itd. Time konsekventno i na sport. Svjetska zajednica se, dakle, suočila sa specifičnom bezbjednosnom krizom koja predstavlja realnu opasnost za opstanak i funkcionisanje gotovo svih subjekata društvene i poslovne interakcije. Efekti protivpandemijskih mjera koje preduzimaju nosioci državne vlasti u borbi protiv COVID-19 generišu različite negativne posljedice koje se reflektuju na rad sportskih organizacija. Kao mjesta organizacijske artikulacije fizičkog vježbanja gotovo svi sportski subjekti doživjeli su specifičan upravljački "stres", sa dominantnom refleksijom na diskontinuitet organizacijskih procesa. Ovakva situacija je dramatično doživljena obzirom da je došla iz eksternog okruženja, naglo i bez prethodnih naznaka o njenom mogućem trajanju i intenzitetu. Kao jedan od mogućih odgovora upravljačkih struktura sportskih organizacija na ovakav poslovni ambijent jeste intenzivnije proučavanje i primjena koncepta Upravljanja kontinuitetom poslovanja. Realizacija BCM-a počiva na adekvatnom planiranju aktivnosti i mjera koje je neophodno primijeniti kako krizna situacija ne bi narušila postavljene koordinate poslovnih procesa u sportskoj organizaciji. Cilj ove teorijske studije je usmjeren na analizu i eksplikaciju determinanti koncepta BCM-a, kao i prepoznavanje mogućih tačaka njene aplikativnosti u upravljanju aktivnostima sportskih organizacija.

Ključne riječi: sportska organizacija, kontinuitet poslovanja, pandemija, COVID-19

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