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SADRŽAJ

DEAR READER,

The new issue of the Sport Science journal has arrived. It brings new scientific papers containing new knowledge and values promoted through the research results of our esteemed authors.

Numerous papers are being delivered to the journal, indicating that researchers have recognised our quality and effort to promote new scientific and professional achievements whose results contribute to sport science.

The Editorial Board has selected the papers for the new issue of Sport Science, where quality is a priority and a requirement for publishing, just like in the previous issues. We would like to thank them for their efforts to select the papers which promote scientific thought and contribute to new findings in sport.

This issue contains papers from Indonesia, India, Greece, Tunisia, Portugal, Vietnam, Serbia, Croatia, Thailand, Italy, Kosovo, Spain, Germany, Turkey, and Bosnia and Herzegovina.

Research on the effects of the COVID-19 pandemic on various aspects of sport is ongoing, and we support such papers that present new knowledge and guide scientific thought towards solutions offering new areas and enriching the existing knowledge with new values.

Sport Science remains a platform for presenting new findings which will contribute to the development of sport science. Promoting the results and achievements represents an obligation for our journal to maintain trust and the quality that will satisfy the needs and expectations of our readers.

That is why we would like to invite the readers to participate in our work so that, together, we could contribute to science and find new solutions for problems in the world of sports.

Nihad Selimović, MD, MSc
Editor in Chief

DRAGI ČITATELJU,

Pred Vama je novo izdanje časopisa Sport Science. Novi broj donosi naučne radove sa novim saznanjima i vrijednostima promovisanim kroz rezultate istraživanja naših cijenjenih autora.

U redakciju časopisa pristižu brojni radovi što ukazuje da su istraživači prepoznali naš kvalitet i nastojanje da promovišemo nova naučna i stručna dostignuća čiji rezultati doprinose nauci o sportu.

Recenzentski odbor je odabrao radove za novi broj časopisa Sport Science gdje kvalitet predstavlja prioritet i uslov za njihovu objavu, kao i u prethodnim brojevima. Zahvaljujemo im se na naporima pri odabiru radova koji promovišu naučnu misao i doprinose novim saznanjima u sportu.

U ovom broju objavljujemo radove iz Indonezije, Indije, Grčke, Tunisa, Portugala, Vijetnama, Srbije, Hrvatske, Tajlanda, Italije, Kosova, Španije, Njemačke, Turske i Bosne i Hercegovine.

Istraživanja efekata pandemije COVID-19 na različite aspekte sporta su i dalje su aktuelna i dajemo podršku takvim radovima koji nude nova saznanja i usmjeravaju naučne misli prema rješenjima koja nude nove prostore i obogaćuju postojeća znanja novim vrijednostima.

Sport Science ostaje platforma za predstavljanje novih saznanja koja će doprinijeti razvoju nauke o sportu. Promocija rezultata i dostignuća je obaveza našeg časopisa kako bi održao povjerenje i zadržao kvalitet koji će zadovoljiti potrebe i očekivanja naših čitatelja.

Zato pozivamo čitatelje da učestvuju u našem radu kako bismo zajedno doprinijeli nauci i pronašli nova rješenja za pitanja u svijetu sporta.

Mr. sci. dr. Nihad Selimović
Glavni urednik

THE EFFECTS OF ELECTROMYOGRAPHIC BIOFEEDBACK TRAINING AFTER MENISCECTOMY: A RANDOMISED CONTROLLED TRIAL

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ABSTRACT

Objective: Investigate the influence of a physiotherapy programme with electromyographic biofeedback in knee extension range of motion and functionality, quadriceps strength, vastus onset timing, and pain in patients submitted to arthroscopic partial meniscectomy. **Methods:** Thirty-three patients between 18 and 55 years old, submitted to arthroscopic partial meniscectomy, were included in the study. Patients were randomly allocated in experimental (EG) (n = 16) and control groups (CG) (n = 17) performing a four-week physiotherapy programme with and without EMG BFB, respectively. The primary outcome measures were passive and active knee extension range of motion, quadriceps strength, motor control, knee functionality, and pain. **Results:** After two weeks, the groups had different active range of motion (p = .031), MVIC 90° (p = .048), MVIC 45° (p = .016) and gait (p = .012). These improvements continued after four weeks in active range of motion (p = .015), MVIC 90° (p = .014), MVIC 45° (p = .006) and gait (p = .013) in the EMG BFB group. Differences in other outcomes were non-significant. **Conclusion:** The inclusion of EMG BFB in a standard physiotherapy programme after arthroscopic partial meniscectomy is effective in improving active knee range of motion, quadriceps strength and gait performance.

Keywords: surgery, meniscectomy, rehabilitation, arthrogenic muscle inhibition

INTRODUCTION

The knee is a complex joint and is vulnerable to several types of injuries. Meniscal tears can be either traumatic or degenerative and are the second most common injury in the knee, with a prevalence ranging from 12 to 14% (Englund et al., 2009; Logerstedt et al., 2018). ž

The incidence rate of meniscus procedures has substantially increased (Logerstedt et al., 2018), with more than 4 million arthroscopic meniscectomies performed each year worldwide (Khan et al., 2014). The

mean annual prevalence of meniscal lesion is 66 per 100,000 inhabitants, 61 of which result in meniscectomy (Logerstedt et al., 2018; Ridley et al., 2017).

After knee surgery, reflex inhibition of motor neurons and immobilisation induce rapid atrophy and weakness in the quadriceps muscle (Akkaya et al., 2012). This muscle weakness is defined as arthrogenic muscle inhibition (Akkaya et al., 2012; Lepley & Lepley, 2021; Norte et al., 2021). During the initial postoperative weeks, some exercises are challenging to perform because of pain, joint effusion, and possibly a disruption in regular joint receptor activity. The distortion of joint receptors' feedback compromises the facilitatory and inhibitory influences on joint musculature, making muscle contraction patterns irregular and less effective (Lepley & Lepley, 2021; Norte et al., 2021). These changes could be a handicap for executing rehabilitative exercises and, consequently, for the recovery of muscle control and strength (Oravitan & Avram, 2013). Impairments in proprioception, muscle strength and knee extension, and poor patient-reported outcomes are present early after meniscal injury and until six months after arthroscopic partial meniscectomy (APM) (Christanell et al., 2012; Logerstedt et al., 2018).

Electromyographic biofeedback could be used in these conditions to restore the quadriceps activation pattern (Akkaya et al., 2012; Cowan et al., 2003; Kirnap et al., 2005; Kushion et al., 2012; Oravitan & Avram, 2013) using surface electrodes to measure underlying muscular activity and converting it to an auditory or visual signal, granting the patient the ability to reach a desired muscular contraction (Giggins et al., 2013; Kim, 2017; Lepley et al., 2012), and it integrates the latest recommendations of physiotherapy guidelines on meniscal lesions (Giggins et al., 2013; Logerstedt et al., 2018).

A recent systematic review highlights that future investigations should explore electromyographic biofeedback (EMG BFB) impact on strength, joint kinematics, muscle activation, dynamic stability, and self-reported outcomes of function (Lepley et al., 2012).

PROBLEM AND AIM

This study objective is to investigate the influence of a physiotherapy programme with electromyographic biofeedback in knee extension range of motion and functionality, quadriceps strength, vastus onset timing, and pain in patients submitted to APM.

MATERIALS AND METHODS

This study was a parallel, blind, randomised controlled trial conducted between January and September 2019, and it was approved by the University Ethics Committee. The trial is registered at ensaiosclinicos.gov.br, number https://ensaiosclinicos.gov.br/rg/RBR-5yhsrrz.

Participants

A total of 33 participants, 12 females and 21 males, with ages ranging between 18 and 55, were recruited from a rehabilitation clinic in Oeiras, Portugal, and randomly assigned in a 1:1 ratio to the experimental group (EG) or control group (CG), starting the respective physiotherapy programme.

Patients of both sexes aged between 18 and 55, who underwent arthroscopic partial meniscectomy less than two weeks before beginning physiotherapy, were included in the study. Patients with concomitant anterior cruciate ligament injury, osteoarthritis greater than grade II, previous surgeries in the ipsilateral knee and with major musculoskeletal or neurological dysfunctions were excluded from the study.

Randomisation

Block randomisation was used to ensure balance in sample size across groups over time (Kang et al., 2008). A team member not involved in the study randomly allocated the blocks in the website randomization.com, concealing the allocation order in numbered opaque envelopes that were opened according to admission order. Participants and assessors were blind regarding the group allocation. The flow chart in Figure 1 represents their progress throughout the trial.

Procedure

Patients that underwent APM were approached and informed by the principal investigator about the study goals and methods, and given the opportunity to sign an informed consent in accordance with the Helsinki Declaration. Patient data was securely stored in accordance with the European Union General Data Protection Regulation and scheduled for deletion in October 2024. Participants completed a socio-demographic survey and the International Physical Activity Questionnaire (IPAQ), followed by assessments of knee extension, quadriceps strength, motor control, knee functionality, and pain, which were repeated at 2- and 4-weeks post-physiotherapy initiation.

Instruments and outcome measures

Quadriceps strength was measured with the handheld dynamometer MicroFET®3 (Hoggan

Scientific, Salt Lake City, Utah, USA). Participants sat and were strapped in the leg extension chair with both legs in front of the equipment lever, which was locked at 90o or 45o of knee flexion to perform three maximum voluntary isometric contractions against the resistance with the dynamometer in each position.

To assess motor control, we measured the vastus medialis obliquus (VMO) and vastus lateralis (VL) onset timing using electromyographic biofeedback PhysioPlux® (PLUX, Lisbon, Portugal). This BFB EMG system has a Samsung tablet connected by Bluetooth® to an Analogue to Digital converter with 12 bits resolution and a sampling frequency of 1000Hz.

Knee functionality was evaluated using the Nijmegen Gait Analysis Scale (NGAS) and Knee Injury and Osteoarthritis Outcome Score (KOOS). NGAS measured gait pattern errors through recordings from anterior and posterior views during a 10-meter walk and lateral view during a 5-meter walk at a comfortable pace. Patients' activity limitations were assessed with the Portuguese version of KOOS, and pain was measured using the Visual Analogue Scale (VAS).

Intervention

The intervention consisted of a standard physiotherapy programme based on the latest Journal of Orthopaedic and Sports Physical Therapy (JOSPT) clinical practice guidelines for meniscal lesions (Logerstedt et al., 2018). The control group underwent a standard physiotherapy programme, while the experimental group completed the same programme along with electromyographic biofeedback three times a week. Sessions included muscle massage, passive and active mobilisation, neuromuscular electrical stimulation, isometric and isotonic exercises, proprioceptive training, and cryotherapy. The physiotherapy programme involved five weekly sessions with the same physiotherapist, who followed a consistent treatment order during each session.

Training programme

On the first week, participants performed 3 sets of each exercise with 15 repetitions with 5s contraction time in isometric exercises, 5s rest between repetitions and 30s between sets. Isotonic exercises in open kinetic chain (OKC) were performed without external load and within the maximum range of motion (ROM) available. By the start of 2nd week, participants progressed to 3-4 sets of 15 repetitions with 10s isometric contractions maintaining the same rest and recovery times. Isotonic exercises were executed with 30% of one repetition maximum (1RM), a 5-minute cycling programme and closed kinetic chain (CKC) exercises without external load were introduced. During the 3rd week, the training programme continued to focus on resistance training, stopping isometric exercises, progressing isotonic to 50-65% 1RM and maintaining CKC exercises. Functional exercises were added during the trial's last week, and external load in isotonic exercises increased to 85% 1RM with 2-3 sets with 3-6 repetitions according to tolerance, with 5s rest and 2 minutes of recovery. Small adaptations to these general indications were made if needed.

Skin was shaved and cleaned with 70% alcohol to ensure electromyographic signal quality, and Ag/AgCl Covidien Kendall® disposable surface EMG electrodes with 24 millimetres diameter were used. The electrodes were placed over the centre of the vastus medialis obliquus and vastus lateralis muscles, aligned with the muscle fibres, and the reference electrode was placed over the anterior tibial tuberosity as described by the Surface Electromyography for the Non-Invasive Assessment of Muscles (SENIAM) recommendations (SENIAM, 2018).

Statistical methods

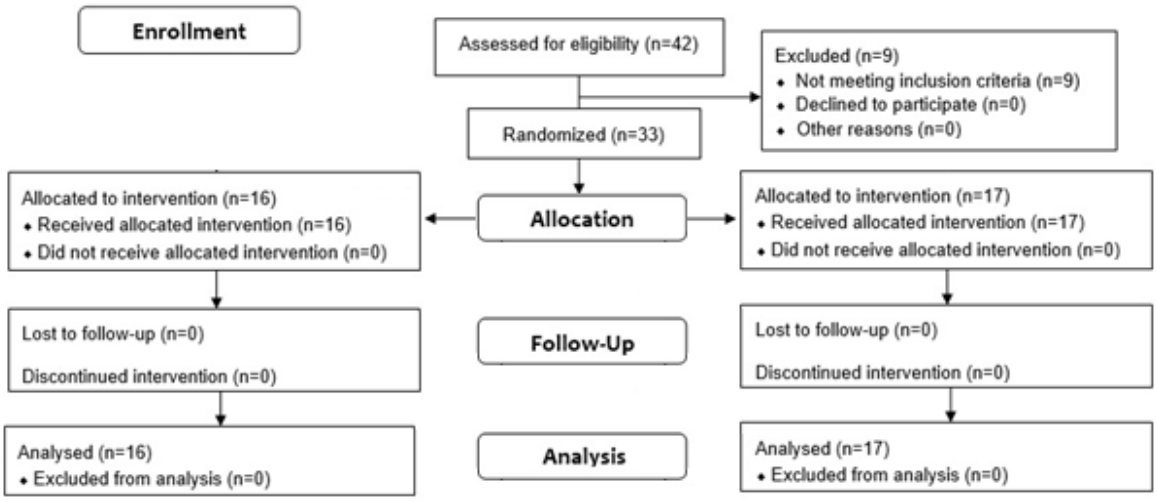
We used the Statistical Package for Social Sciences (SPSS®) 24 software (IBM Corp, Armonk, New York, USA) for the statistical analysis of this study.

Group data was analysed with non-parametric tests, Chi-square for sex and Mann-Whitney U for physical activity variable, and the student's t-test for independent measures was applied to compare groups in age, height, weight, body mass index, education level, and time since surgery. We used the one-way analysis of variance (ANOVA) to compare group effects and a repeated-measures ANOVA to analyse within-group differences and the interaction between within and between effects. Lastly, a linear regression was performed to assess the effect of the intervention and characterisation variables on the outcomes.

RESULTS

The progress of all participants throughout the trial is displayed in the flow chart (Figure 1).

Figure 1. Trial Flow Chart



Forty-two patients submitted to APM were screened for eligibility. Thirty-three satisfied the eligibility criteria, agreed to participate, and were randomised into the experimental group (n = 16, mean ± SD age 40.00 ± 12.25 years; 75% male; 25% female) or the control group (n = 17, mean ± SD age 47.12 ± 11.23 years; 52.9% male; 47.1% female). Baseline features were similar between the groups for all outcomes, as demonstrated in Table 1. The physiotherapy programme was completed by all participants, without dropouts or complications.

Table 1: Baseline Demographics in Both Groups

	Experimental Group (*n* = 16)		**Control Group (*n* = 17)**		**p**
	Mean (± *SD*)	Range	Mean (± *SD*)	Range	
Age (years)	40.00 (± 11.80)	18-55	47.12 (± 11.23)	18-55	.086 [a]
Height (*cm*)	176.00 (± 7.65)	158-192	173.12 (± 8.13)	160-187	.303[a]
Weight (*kg*)	82.06 (± 15.55)	63-120	74.35 (± 11.76)	53-100	.117[a]
BMI (kg/m^2)	26.53 (± 5.11)	21-40.6	24.75 (± 3.30)	20.3-34.6	.241[a]
Education (years)	12.25 (± 1.65)	9-16	12.65 (± 2.85)	4-16	.631[a]
TSS (days)	11.81 (± 2.69)	5-14	13.18 (± 1.47)	9-14	.078[a]
	Frequency (*n*)		Frequency (*n*)		
Sex					
Male	75% (12)		52.90% (9)		.188[b]
Female	25% (4)		47.10% (8)		
Physical Activity					
Low	25% (4)		17.65% (3)		
Moderate	12.50% (2)		23.53% (4)		1.000[c]
High	62.50% (10)		58.82% (10)		

Note. Physical Activity = International Physical Activity Questionnaire Score; SD = Standard Deviation; BMI = Body Mass Index; TSS = Time Since Surgery; Education = Education Level; aStudent's t-test; bChi-square test; cMann-Whitney U test; p = p-value; *p < .05

Patients were recruited over nine months completing a four-week physiotherapy programme, and the experimental group used electromyographic biofeedback while performing the exercise programme. Their knee extension ROM, quadriceps strength, motor control, functionality, and pain were measured before the physiotherapy intervention (O_1), after two weeks (O_2) and after four weeks (O_3).

Both groups had no differences at baseline in all dependent variables. After two weeks, EG had greater active knee extension ROM (p = .031), strength with MVIC at 90° (p = .048) and 45° (p = .016), and less gait errors (p = .012). Those differences continued to increase throughout the study until the fourth week in active range of motion (p = .015), strength at 90° (p = .014) and 45° (p = .006), and gait (p = .013). We did not observe differences between EG and CG in passive knee extension ROM, VM and VL onset timing, KOOS scores, and pain. Detailed results could be consulted in Table 2.

Table 2. Comparison Between Groups for All Outcomes

	EMG BFB (n = 16)	**Control (n = 17)**	**df**	**F**	**p**	**η^2**	***CI* 95%**
	Mean (± *SD*)	Mean (± *SD*)					*MD* [Range]
Baseline							
PKEROM (º)	-6.98 (± 4.61)	-5.43 (± 3.44)	1	1.21	.281	.04	-1.55 [-4.42, 1.33]
AKEROM (º)	-16.88 (± 7.40)	-14.70 (± 7.17)	1	0.74	.397	.02	-2.18 [-7.35, 2.99]
MVIC 90º (*N/Kg*)	10.21 (± 4.15)	12.08 (± 5.69)	1	1.15	.292	.04	-1.87 [-9.39, 12.95]
MVIC 45º (*N/Kg*)	10.13 (± 3.73)	11.24 (± 4.97)	1	0.52	.476	.00	-1.11 [-9.15, 12.25]
Onset (*ms*)	-22.00 (± 68.10)	11.08 (± 44.83)	1	2.75	.107	.08	-33.08 [-73.77, 7.61]
NGAS	8.25 (± 2.62)	6.24 (± 3.35)	1	3.68	.064	.11	2.02 [-0.13, 4.16]
KOOS	47.21 (± 18.24)	52.07 (± 14.59)	1	0.72	.403	.02	-4.86 [-16.55, 6.83]
VAS	2.79 (± 2.53)	2.79 (± 2.43)	1	0.00	.999	.00	0.00 [-1.76, 1.76]
2 weeks							
PKEROM (º)	-3.04 (± 2.69)	-4.55 (± 3.62)	1	1.82	.187	.06	1.51 [-0.77, 3.79]
AKEROM (º)	-6.67 (± 3.92)	-10.63 (± 5.91)	1	5.09	031*	.14	3.96 [0.38, 7.54]
MVIC 90º (*N/Kg*)	18.08 (± 6.05)	13.79 (± 5.93)	1	4.24	048*	.12	4.29 [13.64, 18.10]
MVIC 45º (*N/Kg*)	18.01 (± 5.71)	13.05 (± 5.48)	1	6.48	016*	.17	4.96 [13.31, 17.60]
Onset (*N/Kg*)	-5.29 (± 2.88)	-9.53 (± 21.11)	1	0.63	.432	.02	4.24 [-6.63, 15.10]
NGAS	1.63 (± 1.75)	4.06 (± 3.21)	1	7.18	012*	.19	-2.43 [-4.29, -0.58]
KOOS	60.67 (± 14.84)	60.97 (± 13.57)	1	0.00	.952	.00	-0.30 [-10.39, 9.79]
VAS	1.39 (± 1.32)	1.74 (± 1.59)	1	0.45	.508	.01	-0.34 [-1.38, 0.70]
4 weeks							
PKEROM (º)	-2.33 (± 2.62)	-3.45 (± 3.24)	1	1.18	.286	.04	1.12 [-0.98, 3.22]
AKEROM (º)	-4.23 (± 2.81)	-8.10 (± 5.36)	1	6.62	015*	.18	3.87 [0.80, 6.94]
MVIC 90º (*N/Kg*)	21.17 (± 5.46)	16.01 (± 5.65)	1	6.86	014*	.18	5.07 [16.42, 20.70]
MVIC 45º (*N/Kg*)	21.21 (± 5.68)	15.37 (± 5.79)	1	8.55	006*	.22	5.84 [15.94, 20.47]
Onset (*ms*)	-5.13 (± 3.42)	-7.73 (± 18.84)	1	0.30	.591	.01	2.60 [-7.16, 12.36]
NGAS	0.50 (± 1.10)	2.29 (± 2.52)	1	6.88	013*	.18	-1.79 [-3.19, -0.40]
KOOS	71.53 (± 14.49)	67.54 (± 15.63)	1	0.58	.453	.02	3.99 [-6.73, 14.71]
VAS	0.91 (± 1.21)	1.21 (± 1.40)	1	0.43	.518	.01	-0.30 [-1.23, 0.63]

Note. AKEROM = Active Knee Extension Range of Motion; KOOS = Knee and Osteoarthritis Outcome Score; MVIC = Maximum Voluntary Isometric Contraction; NGAS = Nijmegen Gait Analysis Scale; Onset = Onset timing difference; PKEROM = Passive Knee Extension Range of Motion; VAS = Visual Analogue Scale; ms = milliseconds; N/Kg = Newton for Kilogram; (º) = degrees; SD = Standard Deviation; df = degrees of freedom; F = F-value; p = p-value with one-way ANOVA; η^2 = eta square (effect size); CI = Confidence Interval; MD = Mean Difference; *p < .05

Linear regression

We performed a linear regression to analyse the effect of group, age, BMI, sex, level of education, physical activity, and time since surgery on the outcomes. The group allocation was the only predictor for MVIC 90° (p < 0.001), MVIC 45° (p < 0.001) and NGAS (p = 0.001).

DISCUSSION

The objective of this study was to investigate the effects of the addition of electromyographic biofeedback in a physiotherapy programme on knee extension range of motion, quadriceps strength, motor control, knee functionality, and pain in patients that underwent

arthroscopic partial meniscectomy.

All outcomes improved by implementing a rehabilitation programme as expected, but including EMG BFB was effective in improving active knee extension ROM, quadriceps strength, and gait performance. EMG BFB did not influence passive knee extension range of motion, VMO and VL coordination, activity limitations, and pain progression between groups.

Existing evidence conclude that EMG BFB therapy, in the early phase of rehabilitation, is useful in enhancing knee extension (Christanell et al., 2012), and our results are consistent with that, having an increased active knee extension range of motion after two and four weeks with large effect sizes. An improved VMO activation and muscle function promoted by the addition of EMG BFB allow a wider active ROM and are a probable explanation for the significant differences found in active ROM, as were previously reported by other authors (Christanell et al., 2012). A possible passive ROM limitation did not influence the active ROM results since both groups improved their passive ROM over time, without differences between groups.

Our results revealed a significant impact of EMG BFB in increasing strength during the entire rehabilitation process after APM, which is in accordance with previous studies (Ekblom & Eriksson, 2012; Kirnap et al., 2005; Pietrosimone et al., 2015). Nonetheless, there is conflicting evidence on the effect of EMG BFB on strength, with authors stating that EMG BFB was not effective (Oravitan & Avram, 2013), and two systematic reviews describing that the EMG BFB had positive effects on strength, but its efficacy was not unequivocal (Lepley et al., 2012; Wasielewski et al., 2011). This unclear and conflicting evidence lead these systematic reviews authors into suggesting that further examination of EMG BFB should be conducted to determine its actual effect on strength (Lepley et al., 2012; Wasielewski et al., 2011). Our investigation, following this recommendation, determined its efficacy by finding significant differences between experimental and control groups after two and four weeks, with large effect sizes, both in MVIC at 90º and 45º.

The strength development was one of the main objectives after this surgical procedure, since available evidence suggests that quadriceps weakness after APM is mainly attributable to activation failure and is not related to nerve or muscle injury but is caused by reflex inhibition of motor neurons (Akkaya et al., 2012; Glatthorn et al., 2010). Knowing that muscular strength development is underpinned by a combination of morphological and neural factors, including muscle cross-sectional area and architecture, motor unit recruitment, rate coding, motor unit synchronisation, and neuromuscular inhibition (Folland & Williams, 2007; Suchomel et al., 2018), the exercise programme should target the neural adaptations to revert quadriceps weakness after APM. This objective and the path to achieve it is supported by several authors, who describe that rapid rise in strength within the first two weeks of a training programme is primarily due to neurological adaptations (Folland & Williams, 2007; Vila-Chã & Falla, 2016), and, even though both groups improved strength after two weeks as a consequence of the exercise programme, the inclusion of EMG BFB seem to lead patients to increase muscle activation, enhancing the neural adaptations provided by training, resulting in a development in muscular function as previously described by Wasielewski et al. (2011) in a systematic review. This relation between improved neuromuscular activation patterns and subsequent force production should be taken into consideration (Suchomel et al., 2018), as the enhanced neural adaptations provided by the utilisation of EMG BFB were the probable cause of the significant strength gains from the experimental group. Increased strength in the early stages of an exercise programme due to the referred neural adaptations significantly increases the loading and training stimulus to which the muscle could be exposed, maximizing further strength gains as training continues. (Folland & Williams, 2007). The results after four weeks confirmed this, as the first two weeks' results allowed a more effective strength training during the third and fourth weeks, revealing even greater strength differences between groups by the end of the four-week programme.

We assessed motor control measuring onset timings of vastus medialis obliquus and vastus lateralis using surface electromyography, and the formula (VMO Δt – VL Δt) was applied afterwards to analyse data. The theorised influence of EMG BFB over these muscles onset timings was supported by the consistent evidence that motor learning and retention improved as the focus of attention transitioned from an internal emphasis (e.g., instructing a patient to contract muscles with maximal effort) to an external emphasis (e.g., telling a patient to manipulate a bar graph that represents underlying muscle activation) (Pietrosimone et al., 2015). However, even though both groups went towards a zero value that represented a simultaneous activation of VMO and VL with a slight advantage to the experimental group, they did not have significant differences. Our findings are not in accordance with Oravitan and Avram (2013), who concluded that the decrease of the onset time and offset time were influenced by using EMG BFB in the rehabilitation protocol. The method used for the assessment of the onset timing and the aim of each evaluation are the key factors to understand these conflicting results. We used the time difference between VMO and VL onset to study the inter-muscle coordination, while Oravitan and Avram (2013) used the time difference between an acoustic signal and the VMO and VL onset, which focused on the intra-

muscular coordination. Intra and inter-muscular coordination are both part of exercise-related neural adaptations (Suchomel et al., 2018), and our study results suggest that EMG BFB could have different effects over them.

Several elements of this multifaceted treatment programme promote inter-muscular coordination, making it hard to determine with precision which component or combination of elements was responsible for the change in electromyographic onset timing difference. Current literature confirms that VMO muscle is more affected than VL muscle postoperatively, as several factors, like pain and joint effusion, could cause a decrease in proprioceptive feedback, affecting the execution of the exercises (Kirnap et al., 2005). Therefore, the motor control improvement evidenced in both groups could not be attributed exclusively to the use of EMG BFB during exercises but to multiple influencing factors. The reduction of pain and joint effusion during the treatments allowed the execution of the exercise programme, which has shown to affect the electromyographic onset of VMO relative to VL more than a placebo treatment (Cowan et al., 2003), and the neuromuscular electrical stimulation whose positive influence over muscle activation and function has been previously described (Glaviano & Saliba, 2016). Exercise and NMES appear to have a greater impact on inter-muscular coordination than EMG BFB in the rehabilitation programme, as its addition did not result in significant differences between groups. Investigating the effect of EMG BFB on motor control without NMES would be beneficial to understanding the impact of different modalities on activation timing.

Additionally, other factors could influence the onset of EMG activity, including the amount of EMG background activity and the presence of artefacts like cross-talk (Cowan et al., 2003). Although the study methods comprised and prevented these potential interferences, their possible influence over the onset results cannot be completely discarded.

The results revealed that preforming the exercise programme with EMG BFB is effective in improving the gait pattern throughout the rehabilitation programme. Although both groups had an enhanced gait performance over time, after two and four weeks, the NGAS scores significantly differ between groups, with large effect sizes. Current literature indicates that quadriceps muscle weakness is associated with reduced knee excursion, and that limited knee extension ROM could lead to higher knee flexion angles during lower extremity weight-bearing and consequently to smaller excursion of knee joint contact surfaces during gait, allowing increased focal areas of knee joint contact loading (O'Connell et al., 2016). This weakness and its influence over functional ROM and gait, confirm that postoperative rehabilitation protocols of the knee should include quadriceps muscle strengthening exercises and ROM normalisation to revert the adverse effects on gait pattern, as recommended by Kirnap et al. (2005).

No differences were found on self-reported functionality. Our findings oppose previous studies reporting EMG BFB efficacy in improving functional outcomes (Akkaya et al., 2012; Giggins et al., 2013; Oravitan & Avram, 2013; Wasielewski et al., 2011). However, only Oravitan and Avram (2013) used the KOOS to assess it, while the rest of the studies used the Lysholm Knee Scoring Scale, which could indicate they may have different validity to assess the EMG BFB effects on self-reported activity limitations. Despite the expectation that EMG BFB would improve scores on the KOOS scale by enhancing quadriceps strength, active knee extension ROM, and NGAS, no significant differences between groups were observed. Despite the fact that a systematic review described postoperative use of EMG BFB to alleviate pain as non-conclusive (Wasielewski et al., 2011), our findings reinforce previous evidence that EMG BFB is not effective in reducing pain (Christanell et al., 2012; Oravitan & Avram, 2013). Pain control interventions common to both control and experimental groups seem to contribute to a positive effect over pain, and EMG BFB does not influence that outcome.

The linear regression confirmed the intervention as the only outcome predictor. The effects of EMG BFB on quadriceps strength and gait performance are independent of the characterisation variables of the patients. This fact is of relevance to this investigation's external validity, as its results could be reproduced in patients submitted to arthroscopic partial meniscectomy regardless of their demographic characteristics.

Our study limitations were the inexistence of a pre-operative baseline measure and a follow-up at six months, the use of a handheld dynamometer to assess strength, and the lack of blinding of the physiotherapist. Future studies should address these limitations by including pre-operative baseline measures, longer follow-up times, isokinetic dynamometer for strength assessment, physical performance measures, blinded physiotherapists, and compliance levels. Additionally, different approaches to motor control study, including intra-muscular and inter-muscular coordination, and muscular electric potential balance, should be considered to improve the quality of future studies.

CONCLUSION

Our findings confirm that EMG BFB can enhance quadriceps strength, active knee extension ROM, and gait pattern. It could be used in a rehabilitation programme to reach normal function patterns and daily activities sooner in sedentary patients and in athletes. Our results suggest it could target arthrogenic muscle inhibition consequences in other surgeries.

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Disclosure of interest
The authors report no conflict of interest.

Data availability statement
Study data is openly available in DANS EASY at https://doi.org/10.17026/dans-z9g-73ad

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EFEKTI ELEKTROMIOGRAFSKOG BIOFEEDBACK TRENINGA NAKON MENISCEKTOMIJE: NASUMIČNO KONTROLISANO ISPITIVANJE

SAŽETAK

Cilj: Ispitati efekat programa fizioterapije sa elektromiografskim biofeedbackom na pokretljivost i funkcionalnost ekstenzije koljena, snagu kvadricepsa, vrijeme pojave efekta na vastus mišić i bol kod pacijenata podvrgnutih artroskopskoj parcijalnoj meniscektomiji. **Metode:** Trideset i tri pacijenta u dobi između 18 i 55 godina, a koji su podvrgnuti artroskopskoj parcijalnoj meniscektomiji, je uključeno u studiju. Pacijenti su nasumično podijeljeni u eksperimentalnu (EG) (n = 16) i kontrolnu grupu (CG) (n = 17) te su učestvovali u četverosedmičnom programu fizioterapije sa i bez EMG BFB-a. Glavna mjerenja ishoda su bila pasivna i aktivna pokretljivost ekstenzije koljena, snaga kvadricepsa, motorička kontrola, funkcionalnost koljena i bol. **Rezultati:** Nakon dvije sedmice, grupe su imale različitu aktivnu pokretljivost (p = ,031), MVIC 90° (p = ,048), MVIC 45° (p = ,016) i držanje (p = ,012). Ova poboljšanja su nastavljena nakon četiri sedmice u slučaju aktivne pokretljivosti (p = ,015), MVIC 90° (p = ,014), MVIC 45° (p = ,006) i držanja (p = ,013) u EMG BFB grupi. Razlike u drugim ishodima nisu bile značajne. **Zaključak:** Uključivanje EMG BFB-a u standardni program fizioterapije nakon artroskopske parcijalne meniscektomije je efektivno u poboljšanju aktivne pokretljivosti koljena, snage kvadricepsa i držanja.

Ključne riječi: hirurgija, meniscektomija, rehabilitacija, artrogena mišićna inhibicija

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THE EFFECT OF THE COACH'S VERBAL ENCOURAGEMENT ON MOOD STATE, HEART RATE AND SELF-ESTEEM IN YOUNG SOCCER PLAYERS

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ABSTRACT

Scant research has previously been undertaken to document the effects of verbal encouragement on players aged 12 to 14 during small-sided games. The purpose of this study was to investigate the effects of verbal encouragement on heart rate, mood state and self-esteem of players aged 12 to 14 years after taking part in small-sided soccer games. A total of 14 volunteer male soccer players were divided into two homogeneous groups (a verbal encouragement group and a control group). Participants completed a 10-minute small-sided exercise at the end of each of the experimental sessions scheduled as part of the four-week study. Data were collected on heart rate variation, mood state and self-esteem. Results: Compared to condition where there is a lack of verbal encouragement, participants who received verbal encouragement from their coach experienced a significant increase in heart rate, mood state and self-esteem. Conclusions: The coach's verbal encouragement increased heart rate and improved mood state and self-esteem in young soccer players aged 12 to 14.

Keywords: amateur soccer players, extrinsic motivation, feeling scale, heart rate, self-esteem

INTRODUCTION

Game-based exercises have long been accepted by physical educators and coaches as valuable pedagogical tools to effectively teach team sports (Hill-Haas et al., 2011; Zghibi, 2009; Gréhaigne, 2018; Duprat, 2019; Sahli et al., 2021; Sahli et al., 2022). This type of exercise is conducive to meeting the many aspects and dimensions of team sports, such as the prevailing power-to-weight ratio, the diversity of the sensorimotor system, individual and collective performance strategies, and the fundamental notion of reversibility which affects both behaviours and circumstances (Gréhaigne, 2009).

During team sports competitions, competent players are always expected to switch from one scenario to another, as well as from one behaviour to the other as quickly as possible to efficiently face the

unforeseen events. Therefore, those players are constantly required to develop and maintain physical, technical, tactical, and mental qualities, thereby ensuring high-level performance during competitive matches (Halouani et al., 2019; Selmi et al., 2017) [8, 9]. In this context, training methods involving game-based exercises have been applied to improve player performance (Hill-Haas et al., 2011; Sahli et al., 2021; Sahli et al., 2022; Halouani et al., 2019; Selmi et al., 2017).

In recent years, a growing body of studies has documented that implementing exercises based on small-sided games (SSGs) during training sessions often yield benefits in terms of physical and psychological skills of players (Halouani et al., 2019; Selmi et al., 2017; Sahli et al., 2021). Most of those studies have focused on the effects of this type of exercise on players' mood state, physical euphoria, well-being, and perceived exertion (Sahli et al., 2021; Selmi et al., 2017).

In soccer, SSGs are widely used for coaching purposes (Nachon, 2004). Indeed, evidence abounds in the sport science literature, supporting the potential of SSGs to engage soccer players in exercises and, in turn, promote motivation for training (Sahli et al., 2021; Selmi et al., 2017; Baptista et al., 2018). Undoubtedly high levels of motivation during physical exercise are essential to positive athlete behaviour (Barlett et al., 2011; Selmi et al., 2018).

Verbal encouragement, as an external stimulus driving extrinsic motivation, has previously been shown to increase players' engagement in physical activity, particularly during high-intensity training (Aguiar et al., 2012; Hill-Haas et al., 2011; Sahli et al., 2020).

Several previous studies supported the far-reaching benefits of the coach's verbal encouragement on athletes' physical and psychological parameters (Sahli et al., 2021; Selmi et al., 2017; Aguiar et al., 2012), suggesting that the frequency of small-sided soccer games was significantly higher in training sequences involving the coach's verbal encouragement and that perceived exertion increased significantly in two types of SSGs, namely 2 vs. 2 and 3 vs. 3 games under the coach's verbal encouragement (Sampaio et al., 2007; Selmi et al., 2017). Taken together, these findings highlight the importance of designing training methods in soccer that incorporate the coach's verbal encouragement as a key dimension of the learning process.
The existing literature clearly portrays the positive effects the coach's verbal encouragement can have on athletic performance, particularly during high-intensity training (Sahli et al., 2021; Selmi et al., 2017). SSGs are appreciated by both players and coaches in terms of training outcomes (Hill-Haas et al., 2011; Selmi et al., 2017; Dellal et al., 2012). While players are learning, SSGs can test their physical, physiological, tactical, and psychological skills (Sahli et al., 2021; Selmi et al., 2017). Furthermore, training programmes involving SSGs are likely to improve athletes' physical fitness, psychological resilience, technical skills, and tactical awareness. More interestingly, SSGs suggesting simplified scenarios can enhance players' motivation and engagement in the activity, leading to a more upbeat mood and greater enjoyment of physical activity (Sahli et al., 2021; Selmi et al., 2017; Gonçalve et al., 2016).

PROBLEM AND AIM

The question has been raised whether the coach's verbal encouragement affects the psychological parameters that influence a player's performance on the soccer pitch; more precisely, to what extent can it affect variables such as mood, self-esteem and heart rate in U-14 soccer players?

Proceeding from the above research question, the purpose of this study was to investigate the effects of the coach's verbal encouragement on mood state, heart rate and self-esteem of soccer players aged 12 to 14 years.

METHOD

Participants
A total of 14 male soccer players, aged 12 to 14 years, took part in this study. All players, from the Menzel-Tmim sports club, were divided into two homogeneous equally sized groups, each including 7 players. Medical examinations confirmed that none of the participating players suffered from neuromuscular disorders or musculoskeletal ankle, knee or hip injuries. Before the start of the study, parents/guardians of the players received an informed consent letter containing detailed information about the study procedures. By signing the letter, they approved the participation of their dependents in the study. The study was approved by the local ethics committee of the Higher Institute of Sport and Physical Education of Kef, Tunis (EC-UR22JS01). The protocol was carried out in accordance with the latest version of the 2013 Declaration of Helsinki.

Testing Procedure
Each 7-player team was composed of five field players and two substitutes, knowing that substitutions occurred at the convenience of the players following team-wide collective decisions, with no intervention from the coach. The training programme consisted of eight sessions over the course of two weeks. The coach was instructed to allocate 10 minutes at the end of each

session for a 5 vs. 5 SSG on a mini-soccer pitch (40 × 20 meters).

One researcher allocated all the participants in a randomised crossover design (during each session, one group of participants was supported by verbal encouragement, and the other group performed without verbal encouragement) using a freeware online tool (www.randomizer.org). The coach's verbal encouragement involved expressions such as "Go, Go, Go", "Again", "Move", "Attack the ball", "Intercept", "Keep the ball", "Good", etc.

Throughout the study, SSGs were conducted on the same pitch and within the same time of day to avoid confounders attributable to diurnal variation in performance (Drust et al., 2005). All eight training sessions took place from 4:30 p.m. to 6 p.m.

Heart rate (HR) was measured during the SSGs using the Polar H10 monitor.

Immediately after the SSG, players were asked to rate how they felt during the exercise in terms of core affective sensations ranging from displeasure to pleasure using a 11-point bipolar scale ranging from very bad (– 5) to very good (+ 5) (Hardy & Rejeski, 1989). The analysis showed an ICC of 0.90 (95% CI: 0.80–0.91) for the mood scale.

In addition, general self-esteem was measured using the French version of the Self-Esteem Scale (SES), validated by Vallières and Vallerand (Vallieres & Vallerand, 19190) [23]. The French version of the SES is composed of 10 self-rated items on a 4-point Likert scale - inverted compared to the original version - ranging from (1) "Strongly disagree" to (4) "Strongly agree". The scores of the negatively worded items (3, 5, 8, 9, and 10) have to be reversed in order to calculate a total score that ranges between 10 and 40. The analysis showed an ICC of 0.93 (95% CI: 0.83–0.97) for the self-esteem scale.

Statistical analysis

Data were expressed as means and standard deviations (SD). Normality of data was assessed and confirmed using the Kolmogorov-Smirnov test. The interclass correlation coefficient (ICC) and the 95% confidence interval (CI) were used to determine the consistency of the measures and their variation (test-retest reliability) during familiarisation sessions. All parameters were evaluated using a two (conditions: verbal encouragement, no verbal encouragement) repeated measures ANOVA by session (session 1 to session 8). In the case of condition-by-session, Bonferroni adjusted post-hoc tests were used in the form of pair-wise comparisons. Effect sizes were classified as follows: small > 0.2–0.6, moderate > 0.6–1.2, large > 1.2–2.0, and very large > 2.0. The significance level was set at $p < 0.05$. All analyses were carried out using SPSS 26 for Windows (SPSS, version 27 for Windows. Inc., Chicago, IL, USA).

RESULTS

Mood state data is displayed in Table 1. Significant main effects of the condition ($p < 0.001$; $\eta p2 = 0.85$) were found. However, the analysis indicated no significant condition-by-session interaction ($p = 0.249$; $\eta p2 = 0.27$), and main effects of the session ($p = 0.321$; $\eta p2 = 0.32$) were found.

Peak heart rate data is displayed in Table 2. Significant main effects of the condition ($p < 0.001$; $\eta p2 = 1.01$) were observed. However, the analysis indicated no significant condition-by-session interaction ($p = 0.187$; $\eta p2 = 0.20$), and main effects of the session ($p = 0.201$; $\eta p2 = 0.26$) were found.

Self-esteem data is displayed in Table 3. Significant main effects of the condition ($p < 0.001$; $\eta p2 = 2.19$) were observed. However, the analysis indicated no significant condition-by-session interaction ($p = 0.271$; $\eta p2 = 0.11$), and main effects of the session ($p = 0.197$; $\eta p2 = 0.38$) were found.

Table 1: The effect of the coach's verbal encouragement on mood state

Session	VE	NVE	p (effect size eta-squared [ηp²])		
			Main effect of condition	Main effect of session	Condition by session interaction
Session 1	4.13 ± 0.92**	0.53 ± 1.25	< 0.001 (0.85)	0.321 (0.32)	0.249 (0.27)
Session 2	4.20 ± 0.86	1.33 ± 0.82			
Session 3	3.80 ± 0.94	0.87 ± 0.92			
Session 4	4 ± 0.85	1.07 ± 0.80			
Session 5	4.13 ± 0.92	0.53 ± 1.25			
Session 6	4 ± 1	1.27 ± 0.59			
Session 7	4.07 ± 0.88	1.07 ± 0.59			
Session 8	3.67 ± 0.90	1.27 ± 1.43			

Data were expressed as means ± standard deviations; * significantly different at $p < 0.05$; ** significantly different at $p < 0.01$; *** significantly different at $p < 0.001$.

Table 2: The effect of the coach's verbal encouragement during small-sided games on heart rate

Session	VE	NVE	p (effect size eta-squared [ηp²])		
			Main effect of condition	Main effect of session	Condition by session interaction
Session 1	173 ± 1.64	149 ± 1.25	< 0.001 (1.01)	0.201 (0. 26).	0.187 (0.20)
Session 2	179 ± 0.76	148 ± 0.94			
Session 3	181 ± 0.88	155 ± 0.88			
Session 4	185 ± 1.18	152 ± 0.71			
Session 5	185 ± 1.1	156 ± 0.98			
Session 6	188 ± 0.98	153 ± 0.80			
Session 7	189 ± 0.51	153 ± 1.02			
Session 8	188 ± 0.98	153 ± 0.80			

Data were expressed as means ± standard deviations; VE: verbal encouragement; NVE: no verbal encouragement.

Table 3: The effect of the coach's verbal encouragement during small-sided games on self-esteem

	VE	NVE	Main effect of condition	Main effect of session	Condition by session interaction
Session 1	31.50 ± 3.82*	27.86 ± 1.68	< 0.001 (2.19)	0.197 (0.38)	0.271 (0.11)
Session 2	34.86 ± 1.35	23.38 ± 3.7			
Session 3	31.25 ± 5.63*	23.0 ± 4.47			
Session 4	31.83 ± 4.12	23.50 ± 6.07			
Session 5	32.63 ± 6.41	19.33 ± 1.97			
Session 6	33.5 ± 2.43	24 ± 8.11			
Session 7	34 ± 2.88	17.67 ± 4.50			
Session 8	30.83 ± 6.46	18.75 ± 3.92			

Data were expressed as means ± standard deviations; VE: verbal encouragement; NVE: no verbal encouragement.

DISCUSSION

The results of this study revealed that there was a significant difference in mood between the two conditions, one that received verbal encouragement from the coach (VE) and the other that took part in SSGs under typical conditions, without the coach's verbal encouragement (NVE). Furthermore, these results showed that the group with VE demonstrated higher levels of positive mood than the NVE group. This improvement in mood state may be attributed to the players developing a verbal encouragement strategy during the training sessions. These results are consistent with those of Sahli et al. (2021) who showed that verbal encouragement can improve the mood state of male students participating in soccer drills during physical education classes ($p < 0.001$, ES = 0.60). Furthermore, Sahli et al. (2021) argue that teacher verbal encouragement was perceived by male students as an external factor driving their extrinsic motivation. Similarly, Selmi et al. (2017) compared the effects of high-intensity intermittent training (HIIT) versus low-intensity matches on soccer players' mood state. Their results showed that football players (aged 19-24 years) who engaged in HIIT experienced mood disturbances, while those who participated in low-intensity matches maintained their mood balance. In light of these results, we were able to conclude that simplified SSGs combined with the coach's verbal encouragement can have a beneficial impact on the mood of soccer players aged 12 to 14. Even though it is likely to improve performance, an excessive use of negative encouragement by teachers and coaches should be rather moderate, avoiding potential detrimental effects on motivation and confidence.

The main findings of this study uncovered a significantly greater increase in heart rate values of players who took part in soccer SSGs under the coach's verbal encouragement when compared to players who received no verbal encouragement. The key influence of emotions on the activity of the heart and the vessels is mainly due to the hyperactivity of the axis linking the autonomic nervous system and the adrenal glands (hypothalamic-pituitary-adrenal axis), which results in the production of two hormones: cortisol and adrenaline. While cortisol promotes atherosclerosis, the secretion of adrenaline by the adrenal gland accelerates the heart rate and, this, in turn, increases the force of myocardial contraction; in the arteries, adrenaline causes vasoconstriction, the main effect of which is an increase in blood pressure. As the production of these hormones is extremely rapid, so are the variations in heart rate and blood pressure. According to Sahli et al. (2021), verbal encouragement can affect psychophysiological factors, such as heart rate, lactate levels, perception of task difficulty, as well as perceived enjoyment. Sahli et al. (2021) reported that heart rate and lactate levels of students turned higher after taking part in intense exercises under verbal encouragement.

The findings of this study have also revealed that that the VE team had higher self-esteem levels than NVE. These findings are in agreement with those of Tzetzis et al. (2008) who examined the effects of feedback (positive comments, correction indices, and error indices) on learning outcomes in badminton. The findings of Tzetzis et al. (2008) suggested that the positive comments received from the coach had a beneficial effect on athletes' self-esteem. Similarly, Jones et al. (1997) showed that verbal assertion with a vague goal of "doing your best" increased self-esteem, while a stimulating goal lowered self-confidence scores among competitive athletes. Based on the existing literature, there is still

very little knowledge about the relationship between verbal praise and self-esteem.

There is abundant evidence in the literature of the positive effects of verbal encouragement during exercise on physiological and physical performance. According to Rendons et al. (2019), healthy individuals (aged 19 to 34) produced more work, maximum torque and power during isokinetic tests when the following verbal statements were used: (a) "as quickly as possible" and (b) "as quickly and as quickly as possible. In addition, Sahli et al. (2021) demonstrated that verbal encouragement can improve physical appearance by lowering the maximum heart rate in low-intensity soccer games among students ($p < 0.001$, $\eta p2 = 0.91$).

A limitation of this study is that the students were sampled in small numbers, so there may be differences due to environmental or temporal factors when compared to the other study. Also, the present study employs football as a research tool, and its findings should not be extrapolated to other sports.

CONCLUSION

The purpose of this study was to investigate how coach's verbal encouragement affects heart rate, mood state and self-esteem in soccer players aged 12 to 14 years. The key findings showed that engaging young players in small-sided soccer games under the coach's verbal encouragement contributes to significant improvements in their mood state and self-esteem. Furthermore, the coach's verbal encouragement led to a significant increase in players' heart rate during small-sided soccer games. These simplified games have proven to be effective in persuading players into a more positive attitude. We believe that small-sided games represent a unique challenge for athletes who are likely to perform more efficiently after receiving verbal encouragement from their coach.

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EFEKAT TRENEROVOG VERBALNOG POTICANJA NA RASPOLOŽENJE, SRČANU FREKVENCIJU I SAMOPOUZDANJE KOD MLADIH FUDBALERA

SAŽETAK

Malo je istraživanja provedeno u cilju analiziranja efekata verbalnog poticanja igrača u dobi od 12 do 14 godina tokom igara na skraćenom prostoru. Svrha ove studije je ispitati efekte verbalnog poticanja na srčanu frekvenciju, raspoloženje i samopouzdanje igrača u dobi od 12 do 14 godina nakon učešća u igrama na skraćenom prostoru. Ukupno 14 fudbalera koji su dobrovoljno učestvovali u ovoj studiji je podijeljeno u dvije homogene grupe (grupa verbalnog poticanja i kontrolna grupa). Učesnici su izvršili desetominutnu vježbu igara na skraćenom prostoru na kraju svakog eksperimentalnog treninga planiranog tokom ove četverosedmične studije. Podaci su prikupljeni za varijacije u srčanoj frekvenciji, raspoloženje i samopouzdanje. Rezultati: U poređenju sa situacijom gdje postoji odsustvo verbalnog poticanja, učesnici koje je trener verbalno poticao su imali značajno povećanje srčane frekvencije, raspoloženja i samopouzdanja. Zaključci: Trenerovo verbalno poticanje je povećalo srčanu frekvenciju i poboljšalo raspoloženje i samopouzdanje kod mladih fudbalera u dobi od 12 do 14 godina.

Ključne riječi: fudbaleri amateri, vanjska motivacija, skala osjećaja, srčana frekvencija, samopouzdanje

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COMPARISON OF THE EFFECT OF MODERATE TO HIGH-INTENSITY EXERCISE AND SEDENTARY LIFESTYLE ON SERUM CALCIUM, AND THE ASSOCIATION WITH BLOOD PRESSURE IN HEALTHY MALES

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ABSTRACT

The purpose of this study was to analyse the comparison of the effect of exercise intensity and sedentary lifestyle on serum calcium and its correlation with BP in healthy males. A cross-sectional study was conducted with a total of 134 males, including athletes (n = 102) and non-athletes (n = 32) (the sedentary group) as participants. The athletes were classified into two groups: moderate-intensity exercise (gymnasts, n = 32; soccer, n = 32,) and high-intensity exercise (Tarung Derajat, n = 38). BP was measured using a mercury sphygmomanometer. A Cresolphthalein Complex (CPC) was used to measure serum calcium levels. Serum calcium levels were significantly higher in athlete groups than in the sedentary group ($p = 0.0001$). There was a low positive correlation between serum calcium levels and systolic blood pressure (SBP) and diastolic blood pressure (DBP) in moderate-intensity exercise athletes ($p < 0.005$). A significant difference in SBP was observed in the three athlete groups and the control group ($p = 0.001$). There was a significant difference in DBP between the moderate-intensity exercise athletes and the sedentary group ($p = 0.001$). Regular moderate-intensity exercise is better at maintaining the body's calcium homeostasis and BP. A sedentary lifestyle and high-intensity exercise cause decreased serum calcium levels.

Keywords: exercise, sedentary lifestyle, blood pressure, calcium, 25(OH)D

INTRODUCTION

Regular physical activity is a non-pharmacological therapy for control and prevention of hypertension patients (Pedersen & Saltin, 2015). Long-term physical exercise can significantly reduce blood pressure in both normotensive and hypertensive patients (Bell & Mcintyre, 2014; Saxena, Gupta, Moinuddin, & Narwal, 2016). Moderate-intensity activity significantly reduces the risk of type 2 diabetes, cardiovascular disease, hypertension and premature death (Cornelissen, Smart, & Survey, 2012). Long-term physical exercise causes a series of physiological adaptations from the body's autonomic, hemodynamic, neural, and hormonal systems (Arazi, Asadi, & Chegini, 2016). These adaptations affect the regulation of the cardiovascular system and blood pressure (Monteiro & Filho, 2004). Physical inactivity increases the risk of calcium insufficiency (Peterlik, Boonen, Cross, & Lamberg-allardt, 2009). Chronic calcium insufficiency has an impact on blood pressure regulation and increases the risk of hypertension (Dakshinamurti, 2001). Calcium plays an important role in regulating muscle contractility and optimising the neurological and cardiovascular systems. Calcium also plays an important role in controlling blood pressure in normotensive as well as hypertensive patients (Dakshinamurti, 2001). Calcium is an important ion that functions in the body as a regulator of muscle contraction and relaxation, a second messenger, and an enzyme co-factor, where it regulates the function of the endocrine and nervous systems as well as blood pressure (Pravina, Sayaji, & Avinash, 2015).

Adequate calcium levels in the body are needed to maintain blood pressure homeostasis and remain normal in normotensive people (Dakshinamurti, 2001). Calcium homeostasis in the body is strongly influenced by dietary calcium intake as well as physical activity (Dakshinamurti, 2001). Indonesia is one of a number of Southeast Asian countries with a dietary calcium deficit (Peterlik et al., 2009). Low calcium intake is one of the risk factors for hypocalcaemia (Dakshinamurti, 2001). Hypocalcaemia can cause a decrease in blood pressure ((Dakshinamurti, 2001); Hatton & Mccarron, 1994; Peterlik et al., 2009; Pravina et al., 2015). Long-term hypocalcaemia causes the body to adapt by increasing blood pressure, thus increasing the risk of primary hypertension (Hatton & Mccarron, 1994; Peterlik et al., 2009; Pravina et al., 2015). Chronic hypocalcaemia linearly increases the risk of hypertension (Dakshinamurti, 2001); Hatton & Mccarron, 1994). Untreated chronic hypocalcaemia can cause serious complications such as osteoporosis, cancer, inflammatory and autoimmune diseases, chronic infections, metabolic disorders, cardiac arrhythmia, cardiovascular diseases, and hypertension (Hatton & Mccarron, 1994; Peterlik et al., 2009; Pravina et al., 2015).

Lifestyle modification with regular physical activity is a major preventive factor for essential hypertension (Park et al., 2008). Physical inactivity, or a sedentary lifestyle, is a major risk factor for hypertension and can contribute to approximately 30-50% of the cause of a single case of hypertension (Hamer & Chida, 2008; Whelton, Chin, Xin, & He, 2002). Long-term regular physical exercise showed a significant decrease in blood pressure (Bell & Mcintyre, 2014; Sharman, Gerche, & Coombes, 2014). A sedentary lifestyle is also a risk factor for calcium deficiency (Peterlik et al., 2009). Data from the World Health Organisation (WHO) estimates that, in 2010, the number of people with sedentary lifestyles was approximately 23% of the total population (aged >18 years) of Indonesia (Chan & Chestnov, 2014). Hypertension is a silent disease.(Shrout, Rudy, & Piascik, 2017) It is undetectable, asymptomatic, and linearly increases mortality from complications and other comorbidities (Hedayati, Elsayed, & Reilly, 2011; Hernandez-vila, 2015; Hussain, Mamun, Reid, & Huxley, 2016; Plianbangchang, 2011).

PROBLEM AND AIM

This study is distinct from other research because, in addition to analysing the effects of physical exercise on blood pressure and calcium in young athletes and non-athletes (sedentary group), this study also analyses the effects of moderate and high-intensity exercise on blood pressure and serum calcium levels. This study was conducted to analyse the effects of exercise on blood pressure and the relation to serum calcium levels in young adult athletes and non-athletes (sedentary group).

METHODS

Study Design and Subjects' Description

This study was a cross sectional study. A total of 134 healthy men volunteered in this study, out of which there were 102 athletes and 32 non-athletes (sedentary) aged 17-27. The subjects were classified into two groups: athletes (n = 102) and non-athletes (as a control group) (n = 32) who participated in this research. The athletes were categorised into two groups: those who practiced moderate-intensity exercise (soccer players (n = 32); gymnasts (n = 32) and those who practiced high-intensity exercise (Tarung Derajat; n = 38). Tarung Derajat is a sport that originated in Indonesia.

The inclusion criteria for athletes were: > 12 months of regular training (with a frequency of > 2x/week and

duration of 60-120 minutes/session), not smoking, not drinking alcohol, not consuming calcium supplements or a calcium drug, not consuming vitamin-D supplements or a vitamin-D drug, and being healthy. The inclusion criteria for sedentary subjects were: not exercising regularly or irregularly < 2x/week, never participating in competitions, not smoking, not drinking alcohol, not consuming calcium supplements or a calcium drug, not consuming vitamin-D supplements or a vitamin-D drug, and being healthy.

Measurements

Anthropometric measurements (weight and height) were performed to determine the characteristics of participants. The subjects' body mass index (BMI) was calculated using the formula body weight (kg)/height (m^2). Systolic and diastolic blood pressure was measured using the indirect auscultatory method, performed with a stethoscope and a mercury sphygmomanometer. Blood pressure measurement was performed when subjects were at rest and in a seated position, not during physical activity and not after physical activity.

Serum calcium levels were measured using the Cresolphthalein Complex (CPC) method.21 Chemiluminescence Immunoassays (CLIA) were used to measure serum 25(OH)D levels.22 25(OH)D examinations were performed only in the sedentary group with the goal of determining the cause of hypocalcaemia. Blood sampling was performed in the morning (between 08.00 a.m. and 09.00 a.m.) and in a fasting state (subjects' last meal was at 10.00 p.m. the previous night).

Ethical Approval

The protocols in this study had ethical approval from the ethics committee of the Faculty of Medicine, Syiah Kuala University, Banda Aceh, Indonesia. All participants were volunteers and signed a written informed consent form before the examination.

Statistical Analysis

The data were analysed using a one-way ANOVA ($p < 0.05$) and a linear regression ($p < 0.05$). One-way ANOVA was used to determine the differences in blood pressure and calcium levels between each group of athletes (gymnasts, soccer players, and Tarung Derajat) and the sedentary group. A linear regression was performed to determine the relationship between serum calcium levels and systolic and diastolic blood pressure in the athlete and sedentary groups. Data were analysed using a computer software.

RESULTS

Characteristics of Participants

The characteristics of the participants are shown in Table 1. The characteristics of the subjects measured were age, weight, height, and body mass index (BMI). There was no difference in body weight (BW), height and BMI between the athlete and the sedentary group, but there was a significant difference in age between the groups.

The average age of the Tarung Derajat group makes it the oldest group, but it is still classified into the young adult age.

Table 1: Characteristics of Subjects

	Gymnasts (n = 32)	*Soccer (n = 32)*	*Tarung Derajat (n = 38)*	*Sedentary (n = 32)*	*P value*
Age (years)	26.28 ± 1.25	17.72 ± 2.08	20.22 ± 1.58	18.72 ± 0.45	0.001*
Weight (kg)	59.69 ± 6.77	59.03 ± 5.55	62.53 ± 8.60	60.75 ± 6.32	0.174
Height (cm)	167.16 ± 4.68	166.11 ± 5.55	164.86 ± 7.39	164.84 ± 4.05	0.282
BMI (kg/m^2)	21.35 ± 2.17	21.44 ± 2.32	22.96 ± 2.45	22.40 ± 2.63	0.718

*significant at p-value < 0.05

Comparison of Calcium Serum Levels Between Athletes and the Sedentary Group

Table 2 shows that serum calcium levels were lower in the sedentary group than in the athlete groups ($p = 0.001$). There was a significant difference in systolic ($p = 0.001$) and diastolic blood pressure ($p = 0.001$) between the athlete groups and the control group (sedentary). Table 3 shows that there were significant differences between normal calcium ($p = 0.004$) levels and hypocalcaemia between groups ($p = 0.001$). Most hypocalcaemia was in the sedentary group (78%), which was then followed by the Tarung Derajat group (42.1%). These data suggest that a sedentary lifestyle leads to the occurrence of hypocalcaemia, and high-intensity exercise (Tarung Derajat) has the potential occurrence of hypocalcaemia in a healthy male.

Table 2: Comparison of serum calcium levels, systolic and diastolic blood pressure between groups

	Gymnasts (n = 32)	*Soccer Players (n = 32)*	*Tarung Derajat (n = 38)*	*Sedentary (n = 32)*	p-value
Calcium (mg/dL)	9.61 ± 0.25	9.48 ± 0.36	9.12 ± 0.49	8.99 ± 0.21	0.001*
SBP (mmHg)	120.31 ± 4.74	119.53 ± 5.86	111.58 ± 12.25	104.69 ± 11.06	0.001*
DBP (mmHg)	79.94 ± 5.41	80.62 ± 4.99	71.97 ± 7.50	72.19 ± 7.50	0.001*

SBP: Systolic blood pressure; DBP: Diastolic blood pressure; *significant at p-value < 0.05

Table 3: Comparison of calcium levels (normal and hypocalcaemia) between groups

Calcium	Group								Total Σ	p-value
	Gymnast		Soccer		Tarung Derajat		Sedentary			
	f	%	f	%	f	%	f	%		
Normal	32	100	28	87.5	22	57.9	7	22	89	0.004*
Hypocalcaemia	0	0	4	12.5	16	42.1	25	78	45	0.001*
Total	32	100	32	100	38	100	32	100	**134**	

*significant at p-value < 0.05

Correlation Between Serum Calcium Levels and Blood Pressure in Athletes and the Sedentary Group

Linear correlation analysis shows that there was a low positive correlation between calcium and SBP in male athletes (r = 0.292). The linear correlation value is: > 0.70 = strong; 0.40-0.69 = medium; 0.20-0.39 = low; 0.00-0.19 = very low. The linear regression equation is Y = 58.418 + 6.218X which indicates that an increase in calcium levels of 1 mg/dL will be followed by an increase in SBP as high as 6,218 mmHg. There was a low functional relationship (r = 0.20-0.39) between calcium levels and DBP in male athletes (r = 0.232). The linear regression equation is Y = 41.538 + 3.786X. This equation shows that if there is an increase in calcium levels of 1 mg/dL, it will be followed by an increase in DBP of 3,798 mmHg.

DISCUSSION

The results of this study found that long-term exercise influences the control of blood pressure in the normal range in healthy young adults. A sedentary lifestyle is associated with low blood pressure and low serum calcium levels. Calcium has many important physiological functions, including regulating skeletal, cardiac, and smooth muscle contraction, transmission of nerve impulses, blood clotting, cell division and movement, nerve function, neuromuscular transmission, hormone secretion, and oxidative processes, as well as has a role of a co-factor and second messenger (Blumenthal & Mcevoy, 2015; Pravina et al., 2015). The normal level of blood calcium is 9.2-11 mg/dL (for ages < 20 years old) and 8.3-10.6 mg/dL (for ages > 20 years) (Sherk et al., 2017). Low levels of calcium are caused by many factors such as physical inactivity (sedentary lifestyle), lack of calcium intake, decreased bone resorption, physical inactivity, lack of sunlight exposure, and decreased absorption of calcium by the gut (Bindels, Renkema, Alexander, & Hoenderop, 2008).

The low level of calcium has been a trigger for hypocalcaemia for a long time (Jolma, 2004; Weaver, 2018). Hypocalcaemia may result from lack of calcium intake, decreased bone resorption, physical inactivity, lack of sunlight exposure, and decreased absorption of calcium by the gut (Bindels et al., 2008). The aetiology of hypocalcaemia includes hypothyroidism, resistance to thyroid hormones, and vitamin-D insufficiency (Bindels et al., 2008; Fong, 2012). 25-hydroxyvitamin-D insufficiency causes a decrease of about 50% in calcium absorption in the intestine, and the body only absorbs about 10-15% of the calcium from dietary intake (Fong, 2012; Jeremy & Khan, 2012). Hypocalcaemia is generally asymptomatic but can also cause acute clinical symptoms. Clinical symptoms of acute hypocalcaemia include laryngeal stridor, carpopedal spasm, and tetany (Fong, 2012).

The results showed that systolic and diastolic blood pressure in the sedentary group was lower than in the athlete groups. The results are consistent with the theory that acute hypocalcaemia can result in reduced contraction of the heart, causing hypotension (loss of vascular tone) and heart failure, or both (Fong, 2012). The mechanism of hypocalcaemia and hypotension in

the sedentary is not yet fully known. Hypocalcaemia is not only caused by sedentary lifestyles but also by low-calcium and low-vitamin-D diets (Fong, 2012). However, there is a controversial opinion that decreased calcium intake does not generally result in hypocalcaemia (Pravina et al., 2015). It was an insignificant negative correlation between 25 (OH) D levels and PTH levels in adolescent girls (Sulimani et al., 2016).

Low levels of calcium in the plasma stimulate the body to increase the secretion of parathyroid hormone (PTH) (Singh, Atta, Gupta, Mengi, & Malhotra, 2014; Sulimani et al., 2016). Increased levels of parathyroid hormone result in increased calcium resorption from bone and decreased renal calcium loss. Higher parathyroid hormone levels also stimulate the inactive form of hydroxyvitamin-D (25(OH)2D) to change to its active form of 1.25(OH)2D3 (Singh et al., 2014; Sulimani et al., 2016). The results of this study showed that the average 25-hydroxyvitamin-D (25(OH)D) level in the sedentary group was 14.85 ng/Ml (Hibler et al., 2016). These results indicate that all sedentary subjects have an insufficiency of 25(OH)D. A vitamin-D level below 20 ng/mL is classified as a deficiency. More than 50% of adults have vitamin-D deficiency, 25 (OH) D levels less than 20 ng/mL (Fong, 2012; Singh et al., 2014). Anggarawal found that 88.71% (55/62 cases) of subjects with sedentary lifestyle have vitamin D deficiency. Sedentary lifestyle is associated with vitamin D deficiency (Aggrawal et al., 2017).

Factors that may contribute to Vitamin-D insufficiency in the sedentary group are a lack of sun exposure or a lack of vitamin-D intake (Aggrawal et al., 2017; Peterlik et al., 2009). However, this study does not examine these factors because it is only a preliminary study. This study found that insufficient 25(OH)D in the sedentary group led to a disruption in calcium absorption in the intestine, causing decreased levels of calcium in the blood (hypocalcaemia).

CONCLUSIONS

Moderate intensity exercise is more effective in maintaining the body's calcium homeostasis and also controlling blood pressure compared to high-intensity exercise. Chronic high-intensity exercise, as well as a sedentary lifestyle, can cause a decrease in serum calcium levels and hypocalcaemia in healthy men. Chronic hypocalcaemia is estimated to be a trigger for impaired blood pressure regulation in people with sedentary lifestyles.

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POREĐENJE UMJERENIH I VJEŽBI VISOKOG INTENZITETA SA SJEDILAČKIM NAČINOM ŽIVOTA I NJIHOV UTICAJ NA NIVO KALCIJA U SERUMU TE POVEZANOST SA KRVNIM PRITISKOM KOD ZDRAVIH MUŠKARACA

SAŽETAK

Svrha ove studije je analizirati poređenje uticaja intenziteta vježbi i sjedilačkog načina života na nivo kalcija u serumu te povezanost sa krvnim pritiskom kod zdravih muškaraca. Transverzalna studija je provedena na ukupno 134 muškarca, a kao učesnike je uključila sportiste (n = 102) i one koji to nisu (n = 32) (sjedilačka grupa). Sportisti su podijeljeni u dvije grupe: vježbe umjerenog intenziteta (gimnastičari, n =32; fudbaleri, n =32) i vježbe visokog intenziteta (Tarung Derajat, n = 38). Krvni pritisak je mjeren korištenjem živinog sfigmomanometra. Krezoftalein kompleks (CPC) se koristio za mjerenje nivoa kalcija u serumu. Nivoi kalcija u serumu su bili značajno viši u grupi sportista nego u sjedilačkoj grupi ($p = 0,0001$). Utvrđena je niska pozitivna korelacija između nivoa kalcija u serumu te sistoličkog krvnog pritiska (SBP) i dijastoličkog krvnog pritiska (DBP) kod sportista u grupi vježbi umjerenog intenziteta ($p < 0,005$). Značajna razlika u SBP-u je uočena u tri grupe sportista i u kontrolnoj grupi ($p = 0,001$). Značajna razlika u DBP-u je postojala između sportista u grupi vježbi umjerenog intenziteta i sjedilačkoj grupi ($p = 0,001$). Redovne vježbe umjerenog intenziteta su bolje za održavanje homeostaze kalcija u tijelu i krvnog pritiska. Sjedilački način života i vježbe visokog intenziteta uzrokuju smanjene nivoe kalcija u serumu.

Ključne riječi: vježba, sjedilački način života, krvni pritisak, kalcij, 25(OH)D

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CORRELATION BETWEEN CORE STABILITY AND BALANCE IN TEENAGE FEMALE ROLLER SKATERS

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ABSTRACT

Introduction: As a physical activity, skating requires the introduction of diverse conditions of displacement, resulting in constant balance adjustments with a diminished base of support. There are changes in speed at the beginning, considering the axis of gravity, in the space during the trajectory of displacement, and in the extremities of both the upper and lower body. **Aim:** The aim of the study was to explore the link between core stability and balance in teenage competitive skaters. **Methods:** Teenage female roller skaters (n = 93) within the age group of 12–18 years were evaluated for dynamic balance, static balance and core stability. **Results:** There was significant positive correlation between trunk flexors and dynamic balance (composite score) of right leg ($p < 0.001$) and left leg ($p < 0.001$). Trunk extensors showed positive and significant correlation with the dynamic balance (composite score) of the right ($p = 0.003$) and left ($p = 0.02$) leg. The right and left elbow plank was found to be significantly correlated with the dynamic balance of the right and left leg. The static balance of the right and left leg with open and closed eyes was found to be significantly and positively correlated with the trunk flexor and extensor muscle strength as well. Right elbow plank was significantly correlated with the static balance of the right leg musculature with open and closed eyes. However, the right elbow plank was found to be significantly correlated with the static balance of the left leg with open eyes, but not with closed eyes. Finally, the left elbow plank was significantly correlated to the static balance of the right leg with closed eyes, but not with open eyes. However, there was a significant correlation between the left elbow plank and static balance of the left leg both with open and closed eyes. **Conclusion:** This study suggests that precise training aiming towards core stability should be incorporated with balance training from the performance perspective.

Keywords: static balance, dynamic balance, trunk stability, motor control

INTRODUCTION

Skating is one of the most well-liked games nowadays, which is beginning to take on more of a professional than a leisure significance. Speed skating is a typical example of an ability-leading item group competition, and the major factors that determine an athlete's overall level of sports ability are their physical ability and the skills they have acquired (van Ingen Schenau et al., 2020). Skating is a very difficult sport that requires a special combination of grace, imagination, flexibility, speed, and power (Slater et al., 2016). In India, the kind of skating that utilises roller skates is becoming more and more common.

Roller skating is an aerobic exercise that is beneficial for cardiac health, the development of lower body strength and burning calories (Howard-Shaughnessy & Sluder, 2015). In comparison with the impact jogging has on the body, roller skating has less of an effect on the body. It is a sports activity wherein high intensity, coordinated movements are required along with the additional task of maintaining the posture. Thus, skating is a product of several postural reflexes working together under the control of the neuromuscular system (Koceja et al., 2004).

Optimising the push-off, glide, and landing phases of a turn, a straight line, a departure, or an arrival are essential to good roller skating technique. Therefore, constant sensorimotor control is required, as the body continually shifts to the centre of gravity in response to demands (Moreno et al., 2012), in addition to the ability to fine-tune your centre of gravity within a narrow range of stability (Pinzón-Romero et al., 2019). According to their sporting gesture, the skaters' balance is determined by the location of their centre of gravity in or out of their base of support. In order to resist gravity and reposition their centre of gravity in accordance with the demands of the sport, these factors induce various functional adjustments in postural balance, which are followed by fast muscular contractions at the joints. The aforementioned enables skaters to accelerate and maintain postural balance while avoiding falls and muscular fatigue, hence reducing the risk of injury and relapse (Hrysomallis, 2011). A person is said to have balance when they are able to keep their centre of gravity within their base of support with a minimal amount of postural sway. Balance and coordination are maintained by three different systems that are: the vestibular system, proprioceptive system and visual system. It is the major component of normal daily activities and can be classified as static and dynamic balance (Kovacs et al., 2004).

Building a strong core is important for many different reasons, including sports and functional tasks where you need to be able to move your extremities with relative ease. To achieve the most effective core stability, it is necessary for both the smaller, deeper core muscles and the larger, surface core muscles to contract sequentially and with the appropriate amount of tension (Martuscello et al., 2013). It has been demonstrated that increased stability and neuromuscular control of the lumbopelvic-hip complex reduces the incidence of knee injuries, particularly in females (Fadaei Dehcheshmeh et al., 2021). In a study conducted by Zazulak et al., the researchers found that female athletes who had less trunk control had a higher incidence of knee injuries, particularly damage to the anterior cruciate ligament, compared to female athletes who had stronger trunk control (Zazulak et al., 2007). Roller skating workouts place great demands on the muscular strength and endurance of the upper and lower limbs, waist and belly of the participants, in addition to the flexibility of the hips (Finley, 2010). It is essential for skaters to integrate the strengthening of their core muscles with leaping exercises (plyometrics) so that they can push their muscles in the same way that they are used during the sport. Knapik et al. found that strength and flexibility imbalances in female collegiate athletes were linked to lower extremity injuries in general, but not to the muscle group where the imbalance was found (Knapik et al., 1991). The aerodynamic requirements for peak performance in speed skating place limits not only on the biochemical but also on the physiological aspects of the sport (Hesford et al., 2012). Most speed skating training prioritises conditioned skills like muscle strength, power, speed, and aerobic endurance while downplaying the significance of coordinating skills, particularly postural stability, which has both a dynamic and a static component.

PROBLEM AND AIM

Skating, and more specifically ice-skating or inline skating, has been shown in research to be capable of producing significant improvements in balance of both adolescents and adults (Lange, 2018). There has not been a lot of research done on the effects of roller skating units on balance. Skating on roller skates is a great way for young people to build muscle in their legs and improve their overall fitness. Researchers evaluated the muscular strength and stamina of children and teenagers by testing their ability to perform various upper-body (tennis throw, grip strength) and lower-body (sit-ups, push-ups, curls, standing long jump) exercises (Lopes et al., 2012). Therefore, this research aimed to find the correlation between core stability and balance in teenage female roller skaters.

METHODS

Participants
Ninety-three subjects (n = 93) participated in this correlation study. Convenient sampling technique was used. The research was approved by the Department Ethical Committee of the Faculty of Allied Health Sciences, and it followed the guidelines from the Helsinki Declaration of the World Medical Association, complying with all the relevant national regulations. The sample size was estimated based on the expected effect size (d = 0.3), with 85% of power and a probability of 0.05, and it was found to be 93.

Inclusion and exclusion criteria
Inclusion criteria included teenage roller skater females aged 12-18 years, having a BMI of 18.5-24.9 kg/m^2 in normal rage, having no lower limb injury in the previous six months, no chronic pain or surgery in the lower extremity, dominant right lower extremity, and ready to take part as a volunteer in the study. The participants were excluded if they had any somatosensory disorder that affects balance, any lower limb fracture in the past 6 months, had lower back pain or any musculoskeletal disorder, recent surgical history, such as abdominal, lower limb or any related surgeries, and had uncompensated limb length discrepancy. Their demographic details and medical history were collected through a face-to-face interview. Every participant gave his or her informed consent by signing a document. Anthropometric measurements (height, weight) were taken and BMI calculated for all the subjects.

Procedure
Dynamic Balance (Y balance test)
Participants' ability to maintain their balance while standing on one leg was measured using the YBT which assesses the strength, mobility and proprioception of the lower extremities from three different angles (anterior, posteromedial and posterolateral) (Benis et al., 2016). The distance between the tips of both legs and the midfoot support was measured in millimetres. In order to reduce the learning curve, participants repeated the position six times, and the best score from each of the three assessments was used (Hertel, 2000). If the supporting foot was lifted off the ground, if the body was supported by the extended foot to maintain balance, or if the subject did not return to the starting position, the effort was deemed unsuccessful and the subject was measured again (Plisky et al., 2009). The lengths of both the left and right legs were measured to account for variations in leg length. Each leg length was determined by measuring the distance between the medial malleolus and the anterior superior iliac spine (ASIS). The standardisation formula was used to calculate the mean and standard deviation, and the results were expressed in percentages. The formula for standardisation was as follows: computed value/leg length = 100 (Lee & Ahn, 2018)

Static Balance (Flamingo Balance Test)
The static balance was evaluated using the Flamingo Balance test (FBT) (Alqaraan et al., 2018). It has been demonstrated that the FBT evaluates the balance of the entire body and has an ICC of 0.71. The participants were instructed to stand barefoot on a 4-centimetre-wide wooden plank. While standing on one leg, they flexed the knee of their supporting leg and kept the foot close to their buttocks. After the athlete achieved stability in this position, the timer started, and the evaluation was halted when the athlete lost stability (either by falling off the beam or letting go of the foot being held). There was a 60-second balance test, and the number of times each participant fell was recorded (Kranti Panta, 2015). Although only the dominant leg was examined in the majority of prior investigations, we feel that the bilateral measures in this study will add to the existing body of knowledge.

McGill's Core Endurance Tests
Using McGill's tests, we were able to gauge the participants' core endurance. They were the right and left lateral plank, the trunk posterior extensor test, and the trunk anterior flexor test (Abdelraouf & Abdel-Aziem, 2016). After a brief warm-up to ensure correct posture, each participant performed one test trial in each position to determine how long (in seconds) they could stand still. The results of each test were determined visually by the same observer. The investigator verbally instructed the participant to begin and end the test using the words "start" and "stop," while an assistant investigator recorded the duration using a stopwatch, with the exception of the trunk posterior extensor test, in which the assistant held straps to stabilise the lower body and the investigator determined the start and end of the test. Participants sat with their backs flat on a 600 mm wooden wedge, their hands crossed over their chests, and their knees flexed to an angle of 90 degrees (as measured by a goniometer) for the trunk anterior flexor test. When the wedge was retracted 10 centimetres, the trunk formed an angle of 60 degrees, which triggered the timer.

Participants' feet were stacked on top of each other, their right arm was perpendicular to the floor with the elbow on the mat, the left arm was across the chest, and the left hand was placed on the right shoulder for the left lateral musculature plank test. The plank test for the right lateral musculature is performed in a manner similar to the plank test for the right central musculature, with the exception that the left arm is held parallel to the floor throughout the entire test. Time was halted whenever a researcher noticed the subject's trunk and lower body parts (thigh or shank) were not parallel to one another. Participants laid prone on an examination table with their ASIS on the edge

and their hands on the seat of a chair positioned in front of them at the edge of the table for the trunk posterior extensor test. Participants' lower bodies were held in place by straps held above and below the knees by an assistant. After the timer was started, the participants had to take their hands off the chair and cross them horizontally across their chest.

Statistical analyses
SPSS version 25 was used to perform statistical analysis on the results. Normality analysis was performed using the Shapiro-Wilk test, and the results suggested a normal distribution. Pearson's correlation was used to examine the relationship between different components in each assessment. The correlation coefficients were determined to be weak ($r \leq 0.30$), moderate ($0.30 \leq r \leq 0.50$) and strong ($0.5 \leq r \leq 1.0$). A two-tailed t-test was used, and the level of significance was set at $p \leq 0.05$.

RESULTS

Ninety-three teenage female roller skaters with the mean age of 21.03 ± 1.60, height of 1.49 ± 0.06 cm, weight of 57.02 ± 7.02 kg and BMI of 22.23 ± 2.22 participated in the present study. Table 1 shows the mean and SD of core stability tests, static balance and dynamic balance for both the legs in all directions. The mean of the dynamic balance (YBT test) for the right dominant leg showed a composite score of 89.75 ± 15, compared to the mean of 85.12 ± 14.23 for the left leg. The skaters' mean for the static balance (FBT) of the right leg with open eyes was 52.62 ± 17.76, and that of closed eyes was 9.41 ± 6.39. Similarly, the mean of the static balance for the left leg with open eyes was 44.17 ± 12.93, while it was 6.60 ± .362 for closed eyes. The mean for core stability measured for trunk flexors was 111.29 ± 13.24, and for trunk extensors, it was 110.04 ± 15.79. Furthermore, the selected skaters' mean for the right elbow plank was 99.71 ± 8.46, and for the left elbow plank, it was 96.46 ± 7.43.

Table 2 shows the correlation between the balance (dynamic and static) and all the components of core stability (trunk flexors, trunk extensors, and right and left elbow plank). Core trunk flexors showed positive and moderate correlation ($r \leq 0.50$) with the individual direction and composite score of dynamic balance for the right and left leg. Core trunk flexors were also found to be moderately and positively correlated ($r \leq 0.50$) with the static balance of the right and left leg with open and closed eyes. Core trunk extensors showed weak and positive correlation with anterior ($r = 0.26$) and posteromedial ($r = 0.27$) directions, while there was moderate correlation between core trunk extensors with posterolateral ($r = 0.38$) and composite score ($r = 0.31$) of the dynamic balance of the right leg. However, there was weak correlation ($r \leq 0.30$) between core trunk extensors and all the directions and composite score of the dynamic balance of the left leg. Core trunk extensors further showed weak correlation ($r = 0.24$) with open eyes and moderate correlation ($r = 0.42$) with closed eyes for the static balance of the right leg. Furthermore, core trunk extensors showed moderate correlation ($r = 0.36$) with open eyes and weak correlation ($r = 0.25$) with closed eyes for the static balance of the left leg.

Table 1: Descriptive statistics of balance and core stability

Test	Side	Directions	Mean	95% CI	
				Lower	Upper
Dynamic Balance (YBT)	Right	Anterior	75.30±11.45	72.9	77.7
		Posteromedial	66.2±14.11	63.2	69.2
		Posterolateral	70.89±12.54	68.3	73.5
		Composite Score	89.75±15.40	86.5	93
	Left	Anterior	73.66±13.09	70.9	76.4
		Posteromedial	61.58±11.06	59.3	63.9
		Posterolateral	66.51±11.10	64.2	68.8
		Composite Score	85.12±14.23	82.1	88.1
Static Balance (FBT)	Right	Open Eyes	52.62±17.76	48.9	56.34
		Closed Eyes	9.41±6.39	8.08	10.75
	Left	Open Eyes	44.17±12.93	41.46	46.87
		Closed Eyes	6.60±3.62	5.84	7.35
Core Stability		Trunk Flexors	111.29±13.24	108.52	114.07
		Trunk Extensor	110.04±15.79	106.73	113.35
		Right Elbow Plank	99.71±8.46	97.94	101.48
		Left Elbow Plank	96.46±7.43	94.88	98.03

Furthermore, in regard to the plank test for core stability, right elbow plank was weakly correlated with right anterior ($r = 0.23$) and posteromedial directions ($r = 0.17$) of the dynamic balance test, while it was moderately correlated with the posterolateral ($r = 0.41$) and composite score ($r = 0.31$) of the right dynamic balance. Similarly, there was weak correlation ($r \leq 0.30$) between the left elbow plank and all the directions of the left dynamic balance, and there was moderate correlation ($r = 0.31$) between the composite score of the left dynamic balance test and the right elbow plank. Furthermore, right elbow plank was weakly associated ($r = 0.26$) with the static balance of the right leg musculature with open eyes and moderately correlated ($r = 0.38$) with closed eyes. However, there was weak correlation ($r \leq 0.30$) between the right elbow plank and the static balance of the left leg musculature, both with open and closed eyes.

The correlation between the left elbow plank and all the directions of dynamic balance for the right leg, including the composite score, was found to be moderate ($0.30 \leq r \leq 0.50$). However, the correlation was found to be weak ($r \leq 0.30$) between the left elbow plank and all the directions of dynamic balance for

the left leg, including the composite score. The result between the left elbow plank and static balance of the left leg musculature was the same as for the right leg musculature. The left elbow plank was weakly associated (r = 0.18) with the static balance of the left leg musculature with open eyes and moderately correlated (r = 0.37) with closed eyes. However, there was weak correlation (r ≤ 0.30) between the right elbow plank and the static balance of the left leg musculature, both with open and closed eyes.

DISCUSSION

Roller skating is a competitive, modern sport. Skating requires unusual body movements. The base of support is quite small and is projected onto four wheels that are fixed in place. Sliding over the ground in an oblique orientation creates constant balance shifts and greater instability than other sports. Coordination and balance are crucial factors in sports training (Brachman et al., 2017). The posture control system in skating is regulated by visual, vestibular and somatosensory cues. Proprioceptive receptors sense the body's sway movement to maintain postural control. Balance in speed skating enhances motor abilities and relies on strength; it modifies the body's resting state or movement (static or dynamic balancing) at a given time. Improvements in motor skills can be achieved through balance training even in non-elite athletes (Zhao et al., 2019). The present study was undertaken to study the correlation between core stability and balance. Dynamic balance was assessed with a modified Star Excursion Balance Test, and static balance was assessed with a Single Leg Stance Test. Our findings showed that core stability, specifically the trunk flexor, was strongly and positively correlated with both dynamic and static balance, while the trunk extensor was either weakly or moderately correlated with different components of dynamic and static balance. Balance training enhances spinal reflex excitement via raising supraspinal-induced presynaptic inhibition (Taube, 2008). The skater bends forward and squats up to 60 times while continually crossing their legs. This postural adaptation requires contraction of the quadriceps and gluteus maximus. The muscles in the lower limbs must be strengthened to improve performance. Static balancing training will therefore enhance one-leg standing, which will enhance skate performance (Akahane et al., 2006).

Table 2: Correlation between the balance (dynamic and static) and all the components of core stability (trunk flexors, trunk extensors, and right and left elbow plank)

			Core stability							
Balance			Trunk Flexors		Trunk Extensors		Right Elbow Plank		Left Elbow Plank	
Test	Side	Directions	r	p	r	p	r	p	r	p
Dynamic Balance (YBT)	Right	Anterior	0.552***	<0.001	0.259*	0.014	0.227*	0.031	0.402***	<0.001
		Posteromedial	0.521***	<0.001	0.266*	0.011	0.166	0.117	0.301**	0.004
		Posterolateral	0.55***	<0.001	0.379***	<0.001	0.405***	<0.001	0.339**	0.001
		Composite Score	0.642***	<0.001	0.313**	0.003	0.308**	0.003	0.345***	<0.001
	Left	Anterior	0.517***	<0.001	0.221*	0.037	0.222*	0.036	0.269*	0.01
		Posteromedial	0.537***	<0.001	0.252*	0.017	0.264**	0.012	0.298**	0.004
		Posterolateral	0.545***	<0.001	0.244*	0.02	0.296**	0.005	0.275**	0.009
		Composite Score	0.632***	<0.001	0.255*	0.015	0.306**	0.003	0.279**	0.008
Static Balance (FBT)	Right	Open Eyes	0.517***	<0.001	0.242*	0.021	0.263*	0.012	0.177	0.095
		Closed Eyes	0.501***	<0.001	0.423***	<0.001	0.378***	<0.001	0.326**	0.002
	Left	Open Eyes	0.503***	<0.001	0.363***	<0.001	0.255*	0.015	0.21*	0.047
		Closed Eyes	0.537***	<0.001	0.25*	0.017	0.145	0.173	0.223*	0.035

Inline skating, according to a study conducted by Muehlbauer et al. (2013), might enhance a child's balance (Muehlbauer et al., 2013). They used the Star Excursion Balance Test in a quantitative pretest-posttest research on children aged 11-12 years to measure balance.

Standing on one leg and moving your other leg to different spots all around you represents the execution of the Star Excursion Balance Test, which measures both static and dynamic balance. Post-test scores demonstrated significant improvement in all but one direction, suggesting that a child's balance would improve after a 4-week skating intervention (Muehlbauer et al., 2013). A study was conducted by Katsushi Akahane et al. to find the correlation between leg muscle strength and balance in elite and non-elite speed skaters (Akahane et al., 2006). The study concluded by defining an ultimate necessity to improve the lower limb musculature strength in

speed skaters to improve balance and performance. Planning and creating an intervention that takes into account the athletes' postural control and psychomotor and functional conditions is made easier with an understanding of their current state of static and dynamic balance (Talarico, 2013)

The McGill's core endurance test was used to measure abdominal strength and stability in this investigation. Core stability, or the body's capacity to keep the trunk of the body in place during movement, is comprised of three tiers: the nervous system, the passive system (the ligaments and connective tissue surrounding the joints) and the active system (local and global muscles).

Local muscles are built to contract repeatedly and stabilise particular joints. A regional muscle is the transverses abdominis. Global muscles are larger and span more joints. They tighten up more firmly to offer stability under heavier loads. A universal muscle is the "6-pack" or rectus abdominis. The central nervous system must first send signals to the local muscles that stabilise the core before moving on to the global muscles. At the limits of its range of motion, the passive system stabilises. A common cause of injury is a malfunctioning nervous system or other active system. The problem could stem from a lack of ability, a lack of strength, or an issue with the timing of muscle contractions (i.e., the global muscles take over and work before the local muscles). The spine serves as the hub for all arm and leg motion. For movement to be effective, powerful and coordinated, the spine has to be stabilised by a strong core. Additionally, core stability is crucial for maximum power production and load transfer (Huxel Bliven & Anderson, 2013). Figure skating requires an extremely stable core in order to control the skate on the ice, get the spin or jump tight in the air, keep the body upright during the jump, and stay balanced.

Roller skating is a more superior activity than inline skating for improving static balance (Lange, 2018). One possible explanation is that, in contrast to inline skating, roller-skating requires a greater amount of frictional force, which forces players to work "harder" and increases their lower body strength. The skate's design and the wheels' contact with the surface are both possible causes of the increased friction. The wheels on roller skates are staggered (two in front, two in the back), while on roller blades, they form an inline pattern. The design may require skaters to raise their legs higher during the recovery phase of the gait to prevent the wheels from colliding. This may place a greater demand on the weight-bearing limb, which may improve proprioception and strength in the biomechanics of roller-skating and inline skating. Furthermore, variances in wheel size may be a role in friction.

CONCLUSION

Roller skating is a full-body exercise, since it engages the inner and outer leg muscles, such as the glutes and inner thighs, as well as the core and arms. In addition, due to its low-impact nature, it is easier on the joints than running or jumping rope. In addition, it may be more difficult than other aerobic exercises because it is less obvious and faster than, for example, jogging or running. This implies you must pay closer attention to your balance and concentration.

Practical Applications
From a performance perspective, precise training aimed at improving core stability can be incorporated in the balance training protocol for speed skating, since the relationship between core stability and balance has been established. The skills and knowledge generated can be used to design a programme that improves core stability and, eventually, balance in skaters.

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POVEZANOST IZMEĐU STABILNOSTI TRUPA I RAVNOTEŽE KOD ADOLESCENTICA KOJE SE BAVE ROLANJEM

SAŽETAK

Uvod: Kao fizička aktivnost, rolanje zahtijeva uvođenje različitih položaja, a što dovodi do neprekidnog prilagođavanja ravnoteže uz smanjeni oslonac. U početku dolazi do promjena u brzini s obzirom na osu gravitacije, u prostoru tokom putanje prelaženja iz položaja u položaj te u gornjim i donjim ekstremitetima. **Cilj:** Cilj studije je istražiti povezanost između stabilnosti trupa i ravnoteže kod adolescentica koje se takmiče u rolanju. **Metode:** Adolescentice koje se bave rolanjem (n = 93), a koje su u dobnoj grupi od 12 do 18 godina, su podvrgnute testovima dinamičke ravnoteže, statičke ravnoteže i stabilnosti trupa. **Rezultati:** Značajna pozitivna korelacija je ustanovljena između fleksora trupa i dinamičke ravnoteže (ukupni rezultat) desne ($p < 0,001$) i lijeve noge ($p < 0,001$). Ekstenzori trupa su pokazali pozitivnu i značajnu korelaciju sa dinamičkom ravnotežom (ukupni rezultat) desne ($p = 0,003$) i lijeve noge ($p = 0,02$). Desni i lijevi bočni izdržaj je imao značajnu korelaciju sa dinamičkom ravnotežom desne i lijeve noge. Statička ravnoteža desne i lijeve noge, sa otvorenim i zatvorenim očima, je također imala značajnu i pozitivnu korelaciju sa mišićnom snagom fleksora i ekstenzora. Desni bočni izdržaj je imao značajnu korelaciju sa statičkom ravnotežom mišića desne noge, sa zatvorenim i otvorenim očima. Međutim, desni bočni izdržaj je imao značajnu korelaciju sa statičkom ravnotežom lijeve noge uz otvorene oči, dok to nije bio slučaj sa zatvorenim očima. I konačno, lijevi bočni izdržaj je imao značajnu korelaciju sa statičkom ravnotežom desne noge uz zatvorene oči, dok to nije bio slučaj sa otvorenim očima. Međutim, značajna korelacija je pronađena između lijevog bočnog izdržaja i statičke ravnoteže lijeve noge sa otvorenim i zatvorenim očima. **Zaključak:** Ova studija ukazuje da se, u pogledu učinka, precizni trening usmjeren na stabilnost trupa može povezati sa treningom ravnoteže.

Ključne riječi: statička ravnoteža, dinamička ravnoteža, stabilnost trupa, motorička kontrola

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ACTIVITIES OF FOOTBALL REFEREES DURING GAMES OF DIFFERENT COMPETITION LEVELS – A CASE STUDY

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ABSTRACT

Football has become an extremely dynamic game which requires increased referees' activities. The competition level and game intensity associated with a certain level could affect a referee's activities during the game. That is why we have designed a case study where we followed the activities of an elite UEFA football referee in games of different competition levels. The procedures undertaken included measurements of four variables: distance covered, maximum speed, the number of performed sprints, and distance covered in a sprint, and two derived variables related to the relative share of the distance covered in each halftime and the relative share of the distance covered in a sprint with respect to the total distance covered. All measurements were taken during one game of the European Champions League and one game of the Serbian Super League. The results indicate that there is no difference in total distance covered during both games and maximum speed, but there is obvious difference in the performed sprints and the distance covered in a sprint. Finally, data suggest that there is obvious difference in football referees' activities during the games of different competition levels. Most of the differences concern the sprinting activity, largely related to the level and activity of the players and teams participating in the competition.

Keywords: referee, running, distance, sprint, performance

INTRODUCTION

Football is the most popular game in the world. The simple Laws of the Game, which are the same for all participants in football regardless of age and category, also contributed to this. Since the Laws of the Game cannot predict every situation, the International Football Association Board (IFAB), which decides on the rules of football, has allowed the referees to make decisions according to the spirit of the game (Laws of the game 2022/23).

Referees, as well as football players, must be physically extremely fit in order to be able to follow the dynamics and frequent changes of the game in the field. Football refereeing is a challenging profession. The high-level referee is exposed to physical demands similar to those placed on a midfield football player (Bizzini et al., 2009). Referees' physical abilities are assessed through official FIFA Fitness Tests (Fitness Tests for Match Officials 2020). The level of physical abilities of the referee directly depends on the level of competition in which the referee participates (Castagna et al., 2004; Weston et al., 2006; Bartha et al., 2009).

Football has become an extremely dynamic game

which requires increased referees' activities (Weston et al., 2011). Most of the authors point out that the average distances football players cover during matches are more than 9000 m, and for referees, it is around 10000 m (Di Salvo et al., 2012; Castagna et al., 2004; Weston et al., 2011). No major differences were observed in the distances covered between the two halves. About 41% of the distances during the match covered by referees are at speeds lower than 13 km/h. Sprints never lasted more than 5-6 seconds (Di Salvo et al., 2012). In the Premier League, the referees run 21.3-30.5 sprints at a speed of more than 25.2 km/h during the game (Castillo et al., 2016; Weston, 2010).

According to the relative share of certain types of movement football referees make during the game, 41% run at low intensity (40-60% HR max), 26% run at medium intensity (60-80% HR max), 16% run at high intensity (80- 95% HR max), 10% is walking, 3% is running at maximum intensity (sprint), and 2% is running backwards and running sideways (Da Silva et al., 2008; Di Salvo et al., 2012; Brady et al., 2022).

Di Salvo et al. (2012) showed that an average of 7.3% of referees' activities during the game were greater than 19.8 km/h, and high-intensity activities were the most reliable variable for monitoring the tactical strategy of elite-level referees. With increased match intensity, elite referees perform more submaximal activities without increasing maximal-intensity activities. This shows that the referees at the European competitions are tactically more conscientious, and that is why the negative correlation is shown for the distances covered in high-intensity activities. The referees at the English championship covered a greater distance per sprint than the referees in Premiership, which is a possible consequence of the increased number of attacks and counterattacks in that competition (Di Salvo et al., 2012).

The intensity of football referees' activities is generally submaximal, with frequent changes occurring every 5-6 s. Due to increased activity during the game, referees are monitored for heart rates that average 165 beats per minute. Variation in heart rate was not observed between the first and second half, and there was no change due the importance of the games (Cattarall et al., 1993; Castagna et al., 2004; Dolanski et al., 2017).

However, the referees display a total of more than 1000 activities. Approximately 15% of these activities are sprints, sudden change of direction and short-term high-intensity activities. During these activities, the referees reach a fairly high blood lactate level and high maximum heart rate (similar to players), and energy is provided anaerobically. Therefore, it is important that the main component of the physical capacity needs to be perfect for the referees to show the activity profiles at the highest level in the match, and to make the right and fast decisions (E Silva et al., 2019; Krustrup & Bangsbo, 2001).
In our case study, we set a goal to analyse and compare the activities of one international-level referee in two separate games, where one game is played at the international, and the other one at the national level. We assumed that the referees' activities during these games would be different in accordance with the level of competition.

METHODS

Participants
This research is a case study that follows the activities of one international football referee (Elite group of referees) during two matches with the aim of empirically checking and analysing the collected data on the referee's activities in games of different levels of competition - the Champions League and Serbian Super League. The obtained data were collected by applying the measurement technique using modern monitoring technologies.

Study design
The measurement was carried out during the official games of the Champions League (which was held on 28th September 2021) and Serbian Super League (which was held on 29th August 2021). The time gap between these two games was not too big and amounted to about a month. The importance of a small gap between games affects the validity of the measurement. The smaller the time difference between the two games being analysed, the more valid the analyses are because there was no time to change the referee's physical status with a certain physical preparation programme.

Procedures
To measure the activity of the referee during the game, a watch Polar Vantage M with a heart rate monitor and GPS tracking was used.
For the watch to be functional, it needs to be connected to a computer or mobile phone via the Polar Flow application. When monitoring the activities of the referees, it is necessary to select the running option on the watch and find the heart rate that uses the GPS signal, making the device available in almost all situations.

The monitor on the Vantage M watch uses Precision Prime technology of optical sensors that contain LED lights that penetrate deeper into the skin, and thus accurately and precisely measure the heart rate. The options of the watch are more oriented towards the execution of the run itself, and less towards different statistical processing of the obtained data.

We used several variables of referees' activities during the game: distance covered during the game,

produced speed, the number of sprints performed, and distance covered in sprint. All variables are shown for the whole game, as well as for each halftime. Two more variables were also derived: relative distance covered in each halftime and relative sprint distance with respect to the total distance covered.

Data analysis
In order to determine the differences between the activities of the referee during the matches of different competition levels, data processing analysis using the Polar Vantage M watch and Microsoft Excel 97-2003 software was used.

RESULTS

Based on the data processing of the Polar Vantage M heart rate monitor during the games, the complete activities of the referees are shown in Tables 1 and 2.

Table 1: Activities during the Champions League gamestability

Halftime	1st half	2nd half
Distance covered (m)	4730	3570
Relative distance (%)	53	47
Speed (m/s)	6.54	6.75
Sprints (number)	17	13
Sprint distance (m)	364	355

Table 2. Activities during the Serbian Super League game

Halftime	1st half	2nd half
Distance covered (m)	4270	4530
Relative distance (%)	51	49
Speed (m/s)	6.79	6.51
Sprints (number)	12	11
Sprint distance (m)	320	290

Regarding the distance covered during the game (Fig. 1), the results show that the referee covered 460 m or 10.8% more during the 1st half but 960 m or 21.2% less distance during the 2nd half in the Champions League game than in the Serbian Super League game. In total, the referee covered 500 m or 6% less distance covered in the Champions League game.

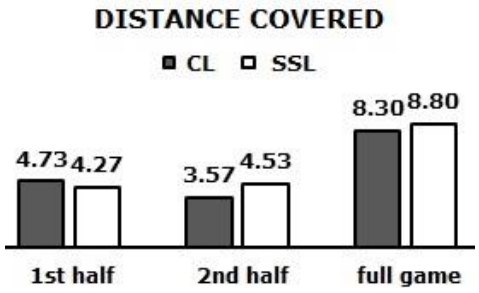

Fig. 1. Distance covered during the games in km (CL – Champions League, SSL – Serbian Super League)

Regarding the maximum speed (Fig. 2), the results show almost identical speed value during both games, with minimal differences when it comes to the parts of the game.

Fig. 2 Maximum speed during the games in m/s (CL – Champions League, SSL – Serbian Super League)

Regarding the total sprint number (Fig. 3), the results show that the referee made 5 or 41.7% more sprints during the 1st half and an almost identical number during the 2nd half in the Champions League match than in the Serbian Super League match. In total, the referee made 6 sprints or 26.1% more in the Champions League match than in the Serbian Super League match.

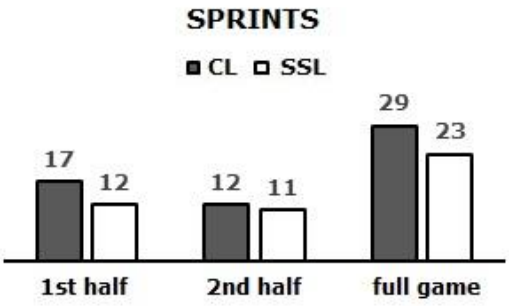

Fig. 3. The number of sprints during the games (CL – Champions League, SSL – Serbian Super League)

Regarding the distance covered in sprint (maximum speed; Fig. 4), the results show that the referee covered 44 m or 13.8% more during the 1st half and 65 m or 22.4% more distance in sprint during the 2nd half in the Champions League game than in the Serbian Super League game. In total, the referee covered 109 m or 17.9% less distance covered in the Champions League game. Relatively, the referee made 8.7% of total distance covered in sprint in the Champions League game, which is more than 6.9% in the Serbian Super League game.

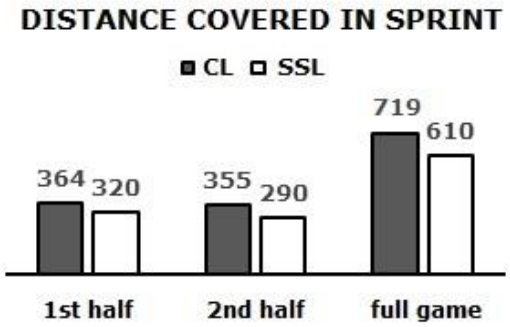

Fig. 4. Distance covered in sprint during the games in m (CL – Champions League, SSL – Serbian Super League)

DISCUSSION

Based on the obtained data and the percentage ratio of the examined variables, it was determined that there are partially significant differences in variables when refereeing various levels of competition.
We can state that a referee who is in the Elite Rank of UEFA referees performs similar activities during games, regardless of the competition level. Also, the analysed and achieved values of the researched variables during this measuring coincide with the values of the elite referees in previous research (Brady et al., 2022; Caballero et al., 2011; D'Ottavio & Castagna, 2001).

In the Serbian Super League game, the referee covered relatively similar distances during both halves. It was noticed that in the second half, he covered a greater distance than in the first half, which is different from previous research, since referees in the second half lose power and move less due to fatigue (Krustrup et al., 2009; Weston et al., 2012). During the Champions League game, a greater difference in the distance covered between the first and second half was observed. In the second half, the referee covered 1160 m less distance compared to the first half, which is 24.52% less. It is also interesting that the referee in the Serbian Super League match covered a greater distance (8800 m) than in the Champions League game (8300 m), which can be explained by the greater responsibility that referees have when refereeing national championships due to pressures of domestic clubs and often unfounded doubts about the regularity of referees' decisions (Krustrup et al., 2009; Dolanski et al., 2017; E Silva et al., 2019).

The maximum speed achieved during matches of various levels of competition is the same, which shows that the referee makes the same efforts and gives his maximum regardless of the level of competition and the importance of the match. The referee reaches high speeds to follow the players' action in a timely manner, and he is always well positioned in relation to the players (Catterall et al., 1993; D'Ottavio & Castagna, 2001; Krustrup & Bangsbo, 2001).

Based on the number of sprints during matches of various levels of the competition, we can see that the referee achieved a higher number of sprints during the Champions League game. The reason for this may be the faster pace of play achieved by the players during the Champions League game, and we can assume that the quality of the players in the Champions League is higher than the quality of the Serbian Super League players. During the matches of the Serbian Super League, in the second half, the pace of the game decreases, and so the number of sprints that the referee has to run decreases (Krustrup et al., 2009; Dolanski et al., 2017).

The referee achieved a greater total sprint distance in the Champions League game by almost 18% compared to the Serbian Super League due to the better fitness of the players and the faster pace of play achieved by football players in the higher levels of the competition. Due to the decrease in the tempo of the game, in the second half, during the games of the Serbian Super League, the distance that the referee has to run in the sprint also decreases (Di Salvo et al., 2012; Krustrup & Bangsbo, 2009; Mallo et al., 2009).

Football players have longer maximum sprints than referees because the referee should be behind the players and well positioned so that he can follow the action in the best way and not interfere with the flow of the game (Weston et al., 2011; Gregson et al., 2010).

The results of this research indicate the importance of football referees during the match. Organisations that are in charge of football referees should pay more attention to the psycho-physical training and fitness of referees, since their activities during games are quite demanding in terms of physical and, even more, mental effort. It is necessary to improve the planning of the training programme, training and adequate nutrition of football referees, strengthening of psychological stability, and introduction of professional referees in more categories of competitions.

Certainly, this study has some limitations that should be taken into consideration. As mentioned earlier, this paper is based on a case study in which the activities of only one referee were measured during two different games. Although both games can be declared as average games in both competitions, it cannot be said with certainty that the observed differences would be followed in other games at the same level of the competition. It would be wise to measure the activities of the same referee during all games in one half-season, and based on the means of all games, conclude about the differences. Unfortunately, even in that case, the problem would be a much higher number of games at the national level compared to the number of matches at the international level (maximum 6 because the group stages of international matches are played over 6 weeks).

Also, due to the mentioned number of games, the importance of a single game in the Champions League is much greater, since each game participates with a greater percentage in the total distribution of points won (Weston et al., 2006).

Finally, not every game is identical regardless of the level of competition. At the same level, there are games that are easier or more difficult to referee. Games without any competitive significance, games for title or survival games, each is different (Castillo et al., 2018). The advantage of the analysed games is that they were played in the first part of the season, and thus the specifics of the end of the season have no influence on the activities during the games.

Finally, data suggest that there is obvious difference in football referees' activities during the games of different competition levels. Most of the differences concern the sprinting activity, largely related to the level and activity of the players and teams participating in the competition. In the future, more variables should be included, like heart rate, sprinting distances, relative share of different intensities, more activities (jumping, striding, change of directions, etc.), and especially more games should be analysed.

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AKTIVNOSTI FUDBALSKIH SUDIJA TOKOM UTAKMICA RAZLIČITIH NIVOA TAKMIČENJA - STUDIJA SLUČAJA

SAŽETAK

Fudbal je postao izuzetno dinamična igra koja zahtijeva izuzetnu aktivnost sudija. Nivo takmičenja i intenzitet igre vezan za određeni nivo mogu uticati na aktivnosti sudije tokom utakmice. Zbog toga smo osmislili ovu studiju slučaja u kojoj smo pratili aktivnosti elitnog UEFA fudbalskog sudije na utakmicama različitih nivoa takmičenja.

Poduzete procedure uključivale su mjerenja četiri varijable: pređene razdaljine, maksimalne brzine, broj izvedenih sprintova i pređene razdaljine u sprintu, kao i dvije izvedene varijable koje se odnose na relativni udio pređene razdaljine u svakom poluvremenu i relativni udio pređene razdaljine u sprintu u odnosu na ukupnu pređenu razdaljinu. Sva mjerenja su izvedena tokom jedne utakmice Europske lige prvaka i jedne utakmice Super lige Srbije. Rezultati pokazuju da ne postoji razlika u ukupnoj pređenoj razdaljini tokom obje utakmice i maksimalnoj brzini, ali postoji očigledna razlika u izvedenim sprintovima i pređenoj razdaljini u sprintu. Konačno, podaci ukazuju da postoji očigledna razlika u aktivnostima fudbalskih sudija tokom utakmica različitog nivoa takmičenja. Većina razlika se odnosi na visoko intenzivne aktivnosti koje su u velikoj meri povezane sa nivoom i aktivnostima igrača i timova koji učestvuju u takmičenju.

Ključne riječi: sudija, trčanje, razdaljina, sprint, učinak

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DETERMINING KNEE PROSTHESES SIZE USING ANATOMIC MEASUREMENTS AND PRINCIPAL COMPONENT ANALYSIS

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ABSTRACT

The purpose of this study was to reduce the number of morphometric parameters observed when designing knee prostheses and to create a prosthesis size system based on the Principal Component Analysis (PCA), a technique to analyse multivariate data. We measured 100 dry femora, 52 of which were male and 48 female. Initially, 11 distal femoral parameters are determined and subsequently reduced using PCA to 3 parameters (Epicondylar Breadth Width, Medial Condyle Width and Lateral Condyle Depth) which we analysed and determined size groups based on the results. We determined 4 size groups for each of the parameters and compared them to manufacturer data and similar data. This study proves that dry femur measurement and Principal Component Analysis can be used to obtain data needed to design knee prostheses.

Keywords: knee, arthroplasty, femur, Principal Component Analysis

INTRODUCTION

Knee prostheses design faces many challenges, most of them based on geometry of the femur and the constant need to improve the knee function of patients that underwent arthroplasty surgery. As a field that usually needs 15-20 years of follow-up research, surgeons or rather manufactures use incompletely researched prostheses, while most of the design is based on anatomical and biomechanical rationalisation rather than clinical data (Scott & Scuderi, 2011). As such, knee design was based on a clear division between anatomic and functional designs in the past; nowadays, the design is based on a mixture of anatomic and functional designs, seeing that orthopaedic surgery and engineering are able to use the best out of both concepts. Adequate selection of prostheses and surgical technique have been identified as the main factors of whether an arthroplasty surgery was successful or not, the

main complications being patellar pain, component loosening and infections. Surgical training and prosthesis selection options are understandably crucial in knee arthroplasty preparation. As to the knee design, historically, problems have risen due to the shortcomings of either anatomic or functional design mainstay (Wirtz, 2011; Jerosch, 2015). The issues include posterior cruciate ligament (PCL) inclusion, excision or hybrid inclusion and the pitfalls of any of them including anterior translation because of the lack or laxity of PCL, paradoxical anterior roll due to tight PCL or tibial osteolysis due to the lack of rotating or mediolateral movement (Scott & Scuderi, 2011; Wirtz, 2011; Jerosch, 2015). Lots of attention is devoted to fixation of components, increasing range of movement or simply finding solutions in reconstructive knee surgery, particularly in revision knee arthroplasty and corresponding prostheses. The listed issues are mostly dealt with effectively due to design innovations, arthroscopic assistance in arthroplasty, availability of research, and more. Part of knee design is naturally the size of the prostheses, seeing that it is challenging designing a universal size parameter of the prosthesis because of the range of morphometric detail in distal femur anatomy (Buechel & Pappas, 2015). The size of the prostheses is particularly important because of the overhang effect an oversized prosthesis has on both the components, particularly the tibial component due to the overwhelming stress resulting in osteolysis and loosening of the component (Scott & Scuderi, 2011; Andriacchi et al., 1986). Knee prostheses size is mostly based on determining a mediolateral and anteroposterior variable which suits the particular knee (Elias et al., 1990; Sedhom et al., 1972; Rostlund et al., 1989). Such a premise has been widely recognised and used in relevant studies. We decided to test the long-stay premise and subsequently create our own system in determining the prostheses size by measuring 11 parameters in 100 dry femora, seeing that classical methods have proven superior to radiographic measurement due to magnification issues (Sedhom et al., 1972). The data was analysed using Principal Component Analysis for dimensionality reduction and determination of size groups, and then compared to other research articles and biotechnology manufacturers.

MATERIAL AND METHODS

We used 100 femora from the Department of Anatomy, Medical School, University of Sarajevo. Out of the 100 femora, 52 were male and 48 were female, all of them adult femora. Femora that had visible pathological alterations and missing parts in the distal femur were excluded from the study. The measurements were made using classical non-digital callipers; all of the measures were presented in millimetres and are based on the work of Martin et al. (1962). The 11 measures taken were: 1. Epicondylar Breadth Width (EBW), 2. Intercondylar Notch Width (ICW), 3. Intercondylar Notch Height (ICH), 4. Maximal Medial Condylar Width (MCWmax), 5. Medial Condylar Width (MCW), 6. Maximal Lateral Condylar Width (LCWmax), 7. Lateral Condylar Width (LCW), 8. Medial Condylar Height (MCH), 9. Lateral Condylar Height (LCH), 10. Medial Condylar Depth (MCD), 11. Lateral Condylar Depth (LCD). The data was analysed with Microsoft Excel, XLSTAT add-on and IBM SPSSS so as to reduce the parameters needed to determine the size of the prostheses.

RESULTS

The initial analysis included making a correlation matrix with the available data based on which conclusions were made in regard to the correlation of individual parameters **(Table 1)**.

Table 1. Correlation matrix for the initial 11 parameters

Variables	EBW	ICW	ICH	MCWmax	MCW	LCWmax	LCW	MCH	LCH	MCD	LCD
EBW	**1**	0.006	0.087	**0.479**	**0.463**	**0.530**	**0.512**	**0.465**	**0.507**	**0.538**	**0.569**
ICW	0.006	**1**	0.161	-0.039	-0.058	0.023	-0.067	0.076	0.081	0.065	0.086
ICH	0.087	0.161	**1**	**0.216**	0.031	**0.226**	0.110	0.100	0.137	**0.314**	**0.287**
MCWmax	**0.479**	-0.039	**0.216**	**1**	**0.616**	**0.635**	**0.517**	**0.525**	**0.583**	**0.609**	**0.664**

MCW	**0.463**	-0.058	0.031	**0.616**	**1**	**0.516**	**0.535**	**0.335**	**0.394**	**0.440**	**0.518**
LCWmax	**0.530**	0.023	**0.226**	**0.635**	**0.516**	**1**	**0.748**	**0.647**	**0.720**	**0.709**	**0.763**
LCW	**0.512**	-0.067	0.110	**0.517**	**0.535**	**0.748**	**1**	**0.511**	**0.580**	**0.664**	**0.676**
MCH	**0.465**	0.076	0.100	**0.525**	**0.335**	**0.647**	**0.511**	**1**	**0.854**	**0.732**	**0.707**
LCH	**0.507**	0.081	0.137	**0.583**	**0.394**	**0.720**	**0.580**	**0.854**	**1**	**0.738**	**0.734**
MCD	**0.538**	0.065	**0.314**	**0.609**	**0.440**	**0.709**	**0.664**	**0.732**	**0.738**	**1**	**0.865**
LCD	**0.569**	0.086	**0.287**	**0.664**	**0.518**	**0.763**	**0.676**	**0.707**	**0.734**	**0.865**	**1**

Initially, it was clear that Intercondylar Notch Width and Intercondylar Notch height correlate poorly with the other parameters and as such could not be used in determining the knee prostheses size. Upon visual inspection, the data indicated that Epicondylar Breadth Width correlates positively with all the other parameters, including ICW and ICH which were previously discarded; such results are synonymous with the results from other authors. Due to the positive correlations of EBW with other parameters, researchers have based their knee prostheses size design on EBW as the main mediolateral parameters while determining an adequate anteroposterior diameter (Sedhom et al., 1972). Whilst such an approach reduces dimensionality in prostheses design, we have decided to take a more methodical approach and chosen to eliminate other parameters not based on analysis in one dimension, but in multiple ones using PCA (Flury & Riedywl, 1988; Jolliffe, 2002; Low et al., 2000). Epicondylar Breadth Width has made the cut and subsequently eliminated 5 other parameters, ICW, MCWmax, MCW, LCWmax, and LCW. Whilst ICW has been eliminated previously, another rationalisation is the fact that EBW = MCWmax + ICW + LCWmax, and as such, choosing EBW eliminates the components it is consisted of. It has been previously agreed upon that we choose MCWmax and LCWmax as measures of both condylar widths, since the results of those measures correlate better with results of other authors, and as such, elminate MCW and LCW, respectively. The parameters of condylar height, MCH and LCH were eliminated based on the fact that none of the knee design studies put much importance on their values. Other than that, measuring MCH and LCH on dry intact femora without performing osteotomy has proved to be challenging from both the design and technical aspects, which was given as a rationalisation to abandon MCH and LCH completely. The condylar depth parameters, MCD and LCD have been dubbed the anteroposterior parameters of the knee prostheses design. Since the main mainstay of the study was to reduce dimensionality, we decided to keep the LCD parameters, seeing that they both correlate highly with each other (0.865) and that LCD has higher values (60 mm mean in LCD versus 58 mm mean in MCD) and could account for a better fit. Since we reduced dimensionality of the knee prostheses size measurements, it is important to note that data analysed with PCA using only two variables tends to have difficulties when reverting back principle component values to original variable values, dubbed as reverting principle component scores. Because of the aforementioned issue, we decided to add another variable that would have the least impact on the obtained values; MCWmax was chosen as the value because it is a part of EBW and would have the least impact on the obtained data. From the aforementioned methods, 3 parameters were determined that would undergo Principal Component Analysis: EBW, MCWmax and LCD. Principal Component Analysis was based on solving the centralised covariance matrix. After centralising and the covariance matrix, we determined the principal component scores. Principal components were visually analysed by a scree plot and axes relationships **(Figures 1, 2, 3, 4, and 5), (Tables 2 and 3).**

Figure 1. Scatter plot for MCWmax vs EBW correlation

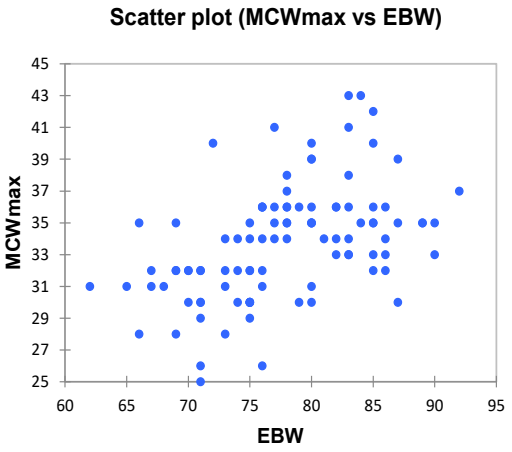


Figure 2. Scatter plot for LCWmax vs EBW correlation

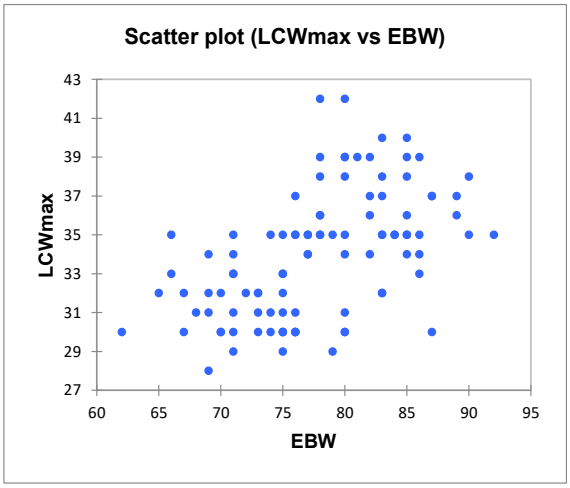


Figure 3. Scatter plot for ICH vs EBW correlation

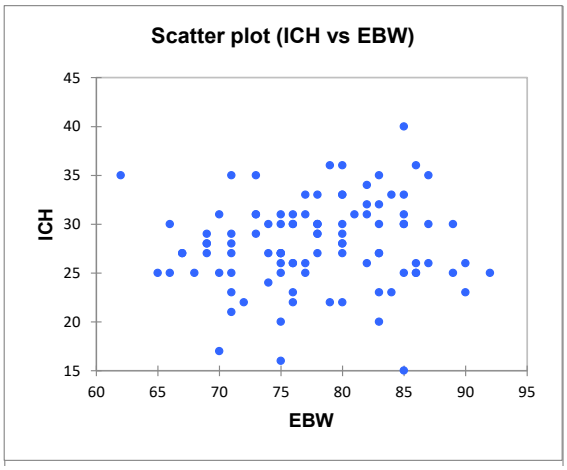


Figure 4. Scatter plot for LCD vs MCD correlation

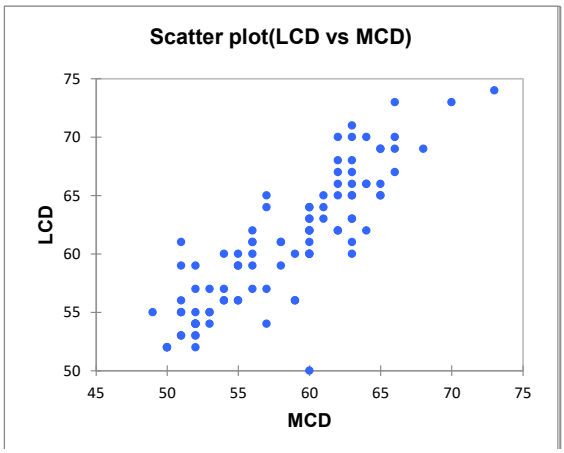


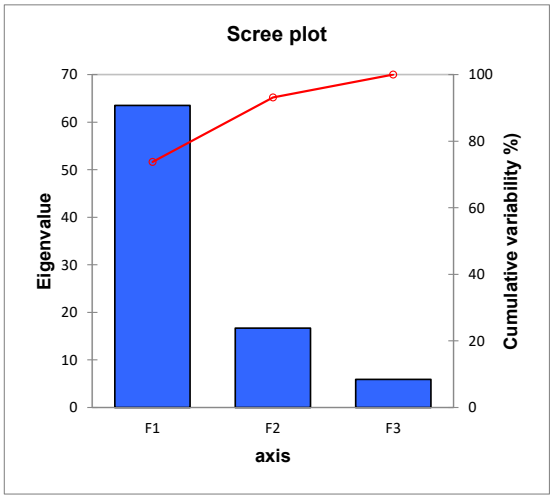
Table 2. Covariance matrix

Variables	EBW	MCW	LCD
EBW	**41.3171**	11.057	20.637
MCW	11.057	**12.8771**	13.447
LCD	20.637	13.447	**31.89**

Table 3. Calculated eigenvectors

	PC1	PC2	PC3
EBW	0.725	0.688	-0.018
MCW	0.320	-0.315	0.894
LCD	0.609	-0.654	-0.448

Figure 5. Scree plot showing that the first variable can be used to explain the needed data



It was determined that the first axis (PC1) could explain most of the presented data, and that the first and third variables (EBW and LCD) correlate the best with the first axis (PC1). Principal component scores were reverted, and the original variables were reconstructed so as to obtain a range of data which was later used to determine the knee prostheses size in this study. Principal Component Analysis reconstruction was solved using the following formulae:

PCA recon. = PC scores – Eigenvectors + Mean

$$Xr = ZV = XVV$$

Xr = reconstructed data; X = centralised covariance matrix data; Z = principal component scores; V = eigenvectors

The obtained data was analysed and passing intervals were created to obtain size groups for the knee prostheses design.

The obtained results were categorised in 3 variables and 4 categories based on the range of obtained data **(Table 4)**. For the EBW, the data range was between 69 and 93 mm; for MCW, the range was 29-41 mm, and for LCD, the range was 54-74 mm. The reconstructed data was compared to the values of the raw data.

Table 4. Initial categories

Variables	A	B	C	D
EBW	**69-75**	75-81	81-87	**87-93**
MCW	29-32	**32-35**	35-38	38-41
LCD	52-57	57-62	**62-67**	**67-72**

Regarding the EBW data, reconstructed values were compatible with the raw data regarding the upper limit but were incompatible in the lower limits. This is due to the fact that we analysed both male and female femora values. When the male and female data are separated, it is clear that the male femora fit the described groups; even group A is not needed since none of the male femora have EBW less than 75 mm. The female femora had 7 EBW values less than 62 mm **(Figure 6, 7, 8, 9, and 10).**

Figure 6. Histogram showing EBW distribution in males

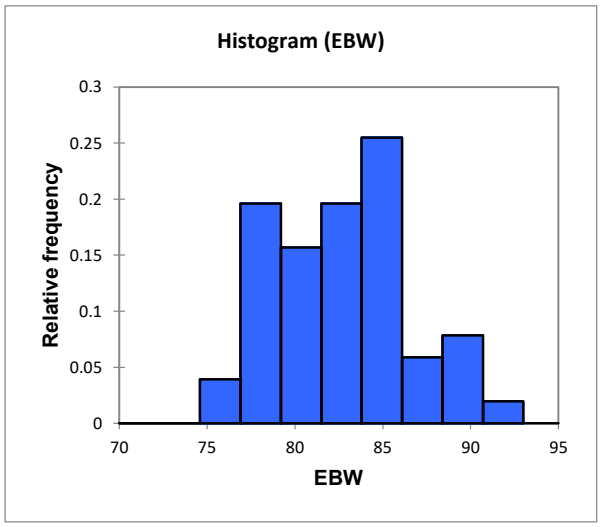


Figure 7. Histogram showing LCD distribution

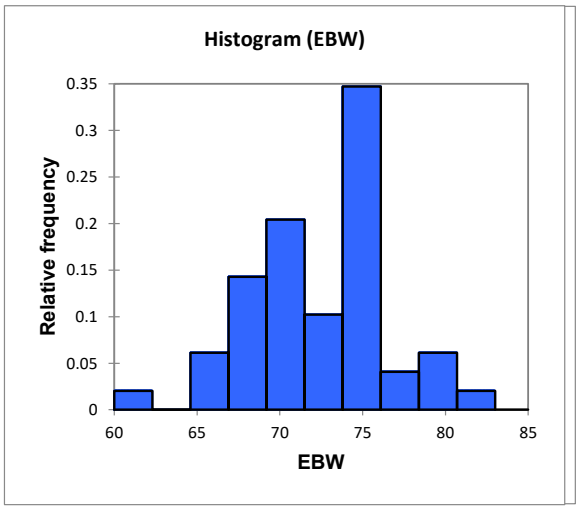


Figure 8. Histogram showing MCWmax values

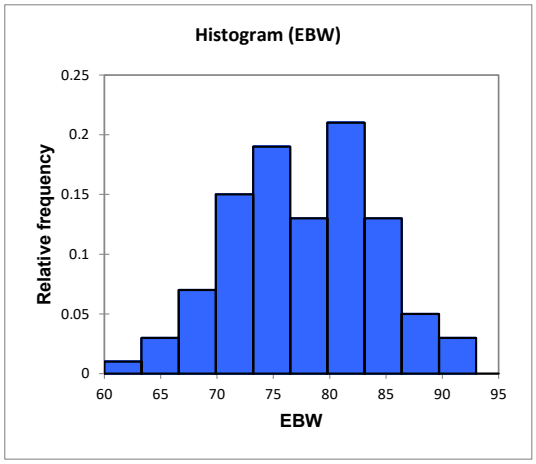


Figure 9. Histogram showing EBW distribution, both genders

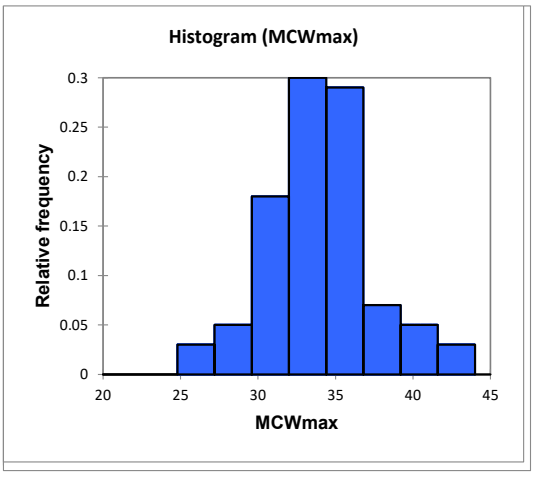
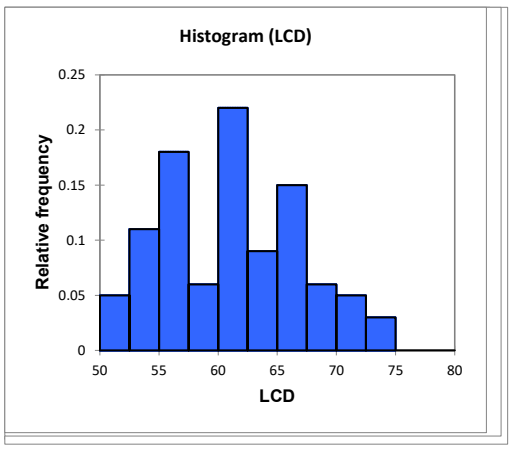


Figure 10. Histogram showing EBW distribution, females



The proposed lowest value is 69 mm, while the female femora did not have values larger than 87 mm. The provided data was then grouped in new size categories that would eliminate the size group A (69-75) for male knees who now have three size groups, and for female knees, the original size group D (87-93) was eliminated and a new group was added with a range of 60-69 mm **(Table 5)**.

Table 5. Mediolateral values for males and females

Variables	A	B	C	D
Males (EBW)	**75-81**	81-87	88-93	
Females (EBW)	**62-68**	68-74	74-80	**80-86**

The MCWmax (or as determined in the tables, MCW) was not analysed due to the fact that it is a part of EBW and that values of EBW are synonymous with MCWmax, LCWmax and ICW. Maximal Medial Condylar Width was picked due to PCA deficits of reconstructing variable scores from only 2 principal component scores, respectively. Lateral Condylar Depth reconstructed values were compared to the LCD raw data, and as such, it was determined that values do not conform in the upper or lower margins of size groups. Particularly, 1 femur did not conform with the lower margin groups, since the LCD value was 50 mm, and 3 femora did not conform with the upper margin values, since their values were larger than 72 mm. Naturally, the lower margin values were not correct for female femora, and the upper margin values were not correct for male femora. The discrepancy was similar but not the same as the one for EBW or mediolateral values, since the upper margin did not conform correctly in addition to the lower value. Since only one value did not conform to the lower margin values, we decided not to change the lower value size groups and the upper margin values, or we should change it to 74 mm so that the D size group has a range from 67 to 74 mm. The newly determined size groups are determined in **Tables 6, 7 and 8.**

Table 6. Anteroposterior values for both genders

Variables	A	B	C	D
LCD	**52-57**	57-62	62-67	**67-74**

Table 7. Final size groups for males

Variables	A	B	C	D
EBW	**75-81**	81-87	88-93	**88-93**
LCD	52-57	**57-62**	62-67	67-74

Table 8. Final size groups, female

Variables	A	B	C	D
EBW	**62-68**	68-74	74-80	**80-86**
MCW	52-57	**57-62**	62-67	67-74

Since MCWmax was determined as irrelevant, only mediolateral (EBW) and anteroposterior (LCD) values were left, and as such, dimensionality reduction was achieved. The new size groups are summarised for male and female femora. The D size group in male femora was determined by the fact that EBW correlate positively with LCD based on the correlation matrix, respectively. Anteroposterior or LCD values are the same for both male and female femora.

DISCUSSION

Other studies have touched upon the theme of determining the knee prostheses design (Elias et al., 1990; Low et al., 2000; Chaichankul et al., 2011; Kim et al., 2016; Hafez et al., 2016). The most similar was the study by Low et al. (2000) which also used PCA as a tool to conduct their studies. They had 11 original variables that they reduced to 5 and then determined the size groups using PCA. They ended up with 6 size groups ranging from extra small (A) to very large (F) for each of the five variables. The five variables determined are basically extend mediolateral and anteroposterior values, so we compared those results with our own identical variables, excluding the variables that were not encompassed in our study. Regarding the mediolateral parameter (in our study EBW, in the Low's study F1), they determined 6 size groups without male and female specific size groups, and we determined 4 size groups for gender specific prostheses, respectively. Low's study determined that we do not need to design prostheses smaller than 59 mm and larger than 69

mm for both genders. Based on our data, none of those prostheses would fit our male femora and would only fit the smallest group of our female knees. Rostlund et al. (1989) also determined both the linear and geometrical parameters of knee prostheses size determination. The total femoral width values were 17 small knees that ranged from 75 mm to 81 mm, 10 medium sized knees with a range from 82 mm to 88 mm, and 9 large sized knees from 89 mm to 95 mm. The author also noted that an acceptable range of variation was ± 3 mm, and as such, the range was from 72 mm to 98 mm at best. The results were comparable with our own, where the sizes correlated well with the male samples, whereas the sizes suggested by Rostlund et al. did not correlate well with our smallest (A) female size group and part of our second smallest group (B). Sedhom et al. (1972) determined that knee size based on total femoral width (equivalent to our EBW) should be divided in four groups ranging from 70 to 94 mm and with a variation of ± 3 mm. The study is comparable with ours, and the results are similar except the fact that our smallest female group encompasses 4 more femora from our study which would not be encompassed by Sedhom's study. As for the anteroposterior diameter, Low's study determined 6 size groups ranging from 47 to 68 mm, whilst we designed 4 size groups ranging from 52 to 74 mm. Low's study could accommodate more knee sizes on the lower threshold, and our study could accommodate more knees one the upper threshold. Although other similar studies did not take the anteroposterior diameter into consideration, the morphometric values are similar throughout knee design articles that had different approaches. This data should apply only to Caucasian knees, since Asian knee size parameters are smaller and implantation of the knee prostheses designed for Caucasians is to be done with caution (Vaidya et al., 2000; Ho et al., 2006; Kim et al., 2016). The same goes for Arabic knees, which are larger than Asian but smaller than Caucasian knees (Hafez et al., 2016; Kim et al., 2016). The downfalls of this study are measurements taken without consideration for rotational dependency of morphometrical parameters like in Low's study and parameter change in different levels of measurement, since we went about the anatomic route (measuring on the defined anatomic landmarks) and not on different self-defined levels like Low's study did. Some studies, like Kim's study, took measurements after compensating from osteotomy that would have taken around the knee. Based on Low's study and the data they provided regarding manufacturer dimensions, it is seen that the anteroposterior dimensions in both the Low's and our study correlate well with the dimension given by the manufacturers. We determined that the mediolateral parameters given by Low et al. were not compatible with a large number of our measured knees. They determined the same based on the data given by the manufacturers. Based on the data given in the study, our obtained results are compatible with all of the sizes the manufacturers provided, even exceeding the largest sizes from Miller Galatne II (85 mm).

CONCLUSION

This study proved that PCA can be a valid method in determining the knee prostheses size based on anthropometric data, since the size groups correlate well with data from other authors and are more appropriate in choosing the knee prostheses size in some aspects. Based on our results, the size groups can be divided into 4 groups, with EBW being the bottleneck feature for male and female specific prostheses, since AP dimensions are the same for both genders. Additionally we conclude that, based on the received size groups, if we want to keep the number of size groups to a minimum, gender-specific knee prostheses should be universally accepted.

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ODREĐIVANJE VELIČINE PROTEZA KOLJENA ANATOMSKIM MJERENJEM I ANALIZOM GLAVNIH KOMPONENTI

SAŽETAK

Svrha ove studije je bila smanjiti broj morfometrijskih parametara uočenih pri dizajniranju proteza koljena te kreirati sistem za veličinu proteze zasnovan na analizi glavnih komponenti (PCA), tehnici za analizu multivarijantnih podataka. Izmjerili smo 100 suhih femura od kojih su 52 bili muški, a 48 ženski. Prvobitno je određeno 11 distalnih femoralnih parametara i nakon toga smanjeno pomoću PCA na 3 parametra (epikondilarna širina, širina medijalnog kondila i dubina lateralnog kondila) koje smo analizirali i na osnovu rezultata odredili grupe veličina. Odredili smo 4 grupe veličina za svaki parametar i uporedili ih sa podacima proizvođača i sličnim podacima. Ova studija dokazuje da se mjerenje suhog femura i analiza glavnih komponenti mogu koristiti za dobijanje podataka potrebnih za dizajniranje proteza koljena.

Ključne riječi: koljeno, artroplastika, femur, analiza glavnih komponenti

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TRAIT ANXIETY DIFFERENCES AMONG PARTICIPANTS IN DIFFERENT TYPES OF DANCE AND GROUP EXERCISE

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ABSTRACT

Anxiety is a major risk factor associated with mental health disorders worldwide. Group exercise is used for anxiety regulation. Dance is a pleasure group physical activity (PA) positively associated with mental health and negatively associated with anxiety. The present study investigated trait anxiety differences in young adults (n = 200) aged 25 to 34 years old, who participated in four different groups: a) Greek traditional dance, b) Latin dance, c) group exercise programmes, and d) sedentary lifestyle, using an observational cross-sectional study design. The State-Trait Anxiety Inventory was used to assess trait anxiety and Leisure Time PA scale was used to assess the participants' PA levels. A one-way univariate analysis of variance (ANOVA) revealed i) higher anxiety scores in Latin dancers than Greek traditional dancers (Mean Difference (MD = 7.39, $p < .001$)), and ii) significantly the lowest amount of PA in sedentary lifestyle from all the other groups. Consequently, dance and mainly Greek traditional dance is positively connected with trait anxiety and mental health.

Keywords: adherence, adults, physical activity, trait anxiety

INTRODUCTION

Anxiety is a significant risk factor associated with mental health problems worldwide. In 2017, the majority of people with a mental health disorder suffered from an anxiety disorder. It amounted to 3.8% of the global population (284 million) and was then followed by depression with 3.4% of the global population (264 million) in the scale of mental disorders (Health online). Unfortunately, these numbers have been increasing. According to the American Psychological Association (2021), anxiety is "an emotion characterized by feelings of tension, worried thoughts and physical changes like increased blood pressure". Anxiety constitutes an increased factor of mortality (Tolmunen et al., 2014) and a risk factor for health-related quality of life reduction (Stein et al., 2005). There is a significant difference between 'state' and 'trait' anxiety. State anxiety is a temporary emotional condition that an individual feels because of the situation they experience, while trait anxiety is more characteristic of somebody's personality, a personality feature (Spielberger, 1983), and expresses the way that somebody reacts in different worries and troubles (Saviola et al., 2020).

Regular exercise is a useful tool to combat anxiety and is able to solve the problems that accompany this (Asmundson et al., 2013; Petruzello et al., 1991). There is an inverse linkup between exercise and anxiety. For example, 19,288 individuals who participated in moderate exercise for 240 minutes per week exhibited less anxiety than non-exercisers (De Moor et al., 2006). Moreover, a risk factor for anxiety disorders can be low levels of PA, while high levels of PA can be a means against anxiety disorders (Kandola & Stubbs, 2020). According to Strohle (2009), developmental, neurobiological and psychological parameters probably comprise the

regulative base between PA and mental disorders in a dynamic way, while exercise prevents the reappearance of decreased mental health (Morgan et al., 2013).

Exercise is more effective in anxiety reduction when compared to other alternative methods such as group therapy, relaxation and music therapy (Wipfli et al., 2008). Group exercise with principles in cohesiveness has superior results in some parameters, like social interaction, adherence and functional effectiveness, than exercise in a standard exercise class which was not different from exercising at home with a contact (telephone calls) (Burke et al., 2006).

Different types of PA are linked with different levels of anxiety. Indeed, among aerobic dance, muscle endurance, hip-hop dance, and ice skating, findings pointed out that the participants in two dance forms presented higher levels of positive mood and lower levels of anxiety than the participants in muscle endurance and ice skating (Kim & Kim, 2007). It was examined whether different forms of exercise differently influence the psychological health of women without and with chronic diseases, and specifically those with hypersensitivity, coronary disease and osteoporosis (Serbezis et al., 2007). The sample was 23 women who participated in three different exercise programmes: a) Greek traditional dance, b) aerobics and c) muscular strength with additional loads. The results pointed out that aerobic and Greek traditional dance programmes improved psychological health and decreased depression. Both aerobic and muscular strength programmes registered an increase in fatigue, something which was not a feature of the Greek traditional dance programme. Furthermore, in other research, participants in Greek traditional dance classes increased their well-being, decreased their state anxiety and distress as opposed to the control group which participated in discussing and watching television sessions, and did not present any differences (Mavrovouniotis et al., 2010).

In the last decade, there is a growing interest concerning the effects of aerobic dance and different types of dance on mental health. Participation in tango dance classes for at least one year leads to stress reduction and improvement of psychological parameters, like emotional state and vitality (Murcia et al., 2009). Additionally, adult participants in jazz dance programmes did not mention any differences in mood, and specifically in depression (Alpert et al., 2009). Young students who participate in Latin dance programmes for 12 weeks improved their social physique anxiety, the perception about how others judge their body (Adilogullari, 2014). Two dance aerobic programmes pointed out a significant reduction of anxiety-tension, depression and aggressiveness, as well as an increase in vitality (Rokka et al., 2010). Those who participated in the research were healthy young adults (n = 136) aged 22 to 40 years old and were separated into two dance aerobic programme groups, one with moderate intensity and one with high intensity. For both groups, there were no differences in fatigue (Rokka et al., 2010). Furthermore, participants in Greek traditional and aerobic dance for 12 weeks (two times per week) did not present any differences (Genti et al., 2008). Both the Greek traditional and aerobic dance groups improved their mood, decreased depression and aggressiveness, and increased vitality (Genti et al., 2008). Additionally, in another set of research findings, 40 overweight and sedentary working women participated in two different groups three times per week for 12 weeks (Mastura et al., 2012). The intervention group attended a dance programme called 'aero mass aerobic dancing' and mentioned a higher improvement of stress than the control group, which attended a typical aerobic dance programme (Mastura et al., 2012). Consequently, it seems that different types of dance relate to different levels of psychological health parameters, like stress, anxiety and depression.

Dance is a pleasure form of PA and has a negative association with anxiety, but the evidence in the field of dance and anxiety is restrictive (Salihu et al., 2021). The aim of the current study was to investigate anxiety differences in young adults who participated in a Greek traditional dance programme (GTD), Latin dance programme (LD), group exercise programme, and sedentary lifestyle, using an observational cross-sectional study design.

METHODS

Participants

The dance clubs that participated in the research were from Athens and other major urban regions in Greece: Eastern Attica, Chalcis (Evoia) and Trikala (Thessaly). The dance clubs had to comply with the following criteria: a) involved in teaching various Greek traditional dances from all geographical regions of Greece, and not specialising in dances only from one or two geographical regions, and b) dance instructors should be Physical Education instructors specialising in GTD.

Inclusion criteria for the volunteers to participate were: a) they should participate only in one organised type of exercise or only one type of dance and not in two or more (e.g., participants in GTD should participate only in one GTD class, participants in LD should participate only in one LD class, and participants in group exercise should participate only in one group exercise class), and b) participants should participate in the specific class (GTD, LD, group exercise) for at least the last 15 months without participating in other type of

exercise or dance during the same period. The dance and exercise participants were given instructions and signed the consent form at the beginning of a dance or exercise session. The questionnaires for the dance groups were administered to the participants during a typical dance class period, avoiding periods of festivals and performances.

Two-hundred adults (151 females, 49 males), who belonged in age category of 25 to 34 years old (Spirduso, 1997), were recruited and divided in four subgroups based on their participation (or lack of it) in organised exercise or dance programmes: a) Greek traditional dancers (GTDs), b) Latin dancers (LDs) (cha-cha-cha, mambo, rumba, salsa, samba, and meringue), c) Pilates/Yoga/whole body exercisers in groups (Group exercisers: GEs), and d) sedentary lifestyle group, who did not participate in any organised form of exercise or dance for the same period. The Exercisers and Sedentary group participants were selected from the same regional areas as the dancers. PA adherence (dance or exercise) of the participants was recorded as their experience years. Before filling in the questionnaires, the participants were given verbal relative instructions. Participants' characteristics can be found in Table 1.

The study adhered to the Declaration of Helsinki and was approved by the Ethics Review Board of the University of Thessaly, Department of Physical Education and Sport Sciences (Protocol number 2-4/10-10-2012).

Table 1. Participant's characteristics

Age category	Group	Age (years; M ± SD)	Experience (years; M ± SD)	PA (MET; M ± SD)	N
25-34 years (n = 200)	Sedentary	29.5 ± 4.2	–	18.7 ± 13.1	50
	Exercisers	30.1 ± 4.5	1.4 ± 2.97	29.7 ± 15.6	50
	GTDs	30 ± 3.5	4.4 ± 6.7	30.3 ± 17.9	50
	LDs	28.6 ± 3.4	1.47 ± 1.76	34.3 ± 15.9	50

Notes. M: Mean; SD: Standard Deviation; PA: Physical Activity; MET: Metabolic Equivalent; GTDs: Greek traditional dancers; LDs: Latin dancers

Table 2. Years of experience among GTDs (Greek traditional dancers), LDs (Latin dancers) and Exercisers

		Exercisers	**GTDs**	**LDs**
25-34 years old	min	2	2	2
	max	15	22	10

Instruments

Trait anxiety

The State-Trait Anxiety Inventory (STAI-Trait) (Spielberger et al., 1983) was used to assess personal differences in the way that people experience stressful situations in daily life. Participants reply according to how they feel generally in their life. The questionnaire consists of 20 questions measuring trait anxiety, while participants' responses are given in a four-point Likert scale (0 = almost never, 4 = almost always). In the present study, the Greek version of the STAI-Trait questionnaire was used (Kakkos et al., 1991; Liakos & Giannitsi, 1984). The Cronbach's alpha index in the Greek population is about .84 to .86 (Liakos & Giannitsi, 1984). The Cronbach's alpha index in the present study was .72.

Physical activity

The Leisure Time PA (Godin & Shephard, 1985) questionnaire was used to assess participants' PA levels. It consists of three items and examines the participant's frequency and intensity of PA during their spare time. The questionnaire determines the frequency of participation in high, medium and/or low intensity exercise for > 15 minutes during the last week. The score is calculated as follows: Weekly leisure-time activity score = (9 x frequency of strenuous PA) + (5 x frequency of moderate PA) + (3 x frequency of mild PA) in units. This scale has been previously used for the Greek population with good credibility and validity (Psaltopoulou et al., 2004). The participants' characteristics are presented in Table 1.

Statistical analysis

Initially, normal distribution via skewness (< 7) and kurtosis (< 2) was also tested (Kim, 2013). Then, descriptive statistics (mean, standard deviation) and reliability analysis were calculated for the examined variables. A one-way univariate analysis of variance (ANOVA) was used to assess the differences in trait anxiety as far as the participation group is concerned. The dependent variable was the score of the anxiety scale (STAI-Trait). The independent variables were: a) age group (25-34 years) and b) participation: (i) GTD, (ii) LD, (iii) Exercisers, and (iv) sedentary lifestyle group. Sidak post hoc tests were used to test group differences.

Similarly, a one-way analysis of variance (ANOVA) was used to assess the differences in the participants' PA levels. The dependent variable was the total exercise index. The independent variables were the groups: (i) GTD, (ii) LD, (iii) Exercisers, and (iv) sedentary lifestyle group. Sidak post hoc tests were used to test group differences. All analyses were conducted using IBM SPSS Statistics version 26, while the p-value was set at .05.

RESULTS

We found a main effect of the participation group ($F_{3,183}$ = 2.85, $p < .05$, $\eta_p^2 = .04$) regarding anxiety. According to post hoc tests, GTDs had a significantly lower anxiety score than LDs (MD = 7.39, $p < .001$) while LDs presented a higher anxiety score than GTDs (MD = 7.39, $p < .001$) and the sedentary group (MD = 5.40, $p < .05$). Table 3 displays the descriptive statistics of anxiety. We also found that there was a significant main effect of the group ($F_{3,185}$ = 8.48, $p < .001$, $\eta_p^2 = .12$) regarding the amount of PA. The sedentary group presented the lowest amount of PA when compared to all the other groups, GTDs (MD = 11.62, $p < .01$), LDs (MD = 15.67, $p < .001$), and Exercisers (MD = 10.99, $p < .01$). In contrast, these three groups (GTDs, LDs and Exercisers) had no significant differences. Table 1 displays the descriptive statistics of PA.

Table 3. Descriptive statistics of anxiety in four groups of young adults GTDs: Greek traditional dancers; SD: Standard Deviation

	Anxiety	
	M	SD
GTD	38.21*	7.59
Latin dancers	45.60*#	10.37
Group exercisers	41.78	8.17
Sedentary participants	40.20#	8.87
Total	41.23	9.04

* Significant differences between LDs and GTDs ($p < .001$)

\# Significant differences between LDs and sedentary participants ($p < .05$)

DISCUSSION

The aim of the present study was to examine trait anxiety differences among the GTD programme, LD programme, GEs, and sedentary lifestyle in young adults. We found that GTDs presented lower levels of trait anxiety than LDs. These results probably are due to GTD characteristics, like group cohesion, adherence and music.

According to Yalom (1985), one basic criterion for group cohesion development is that members must experience the activities of the group as rewarding. During GTD class, in order for participants to feel fulfilled and satisfied with the dance session, everyone should be able to dance in a similarly satisfying way. The better each person dances the greater is the overall feedback that each one receives. On the contrary, during LD, each dancer is able to complete and fulfil the dance by himself/herself or at least with one more person. Sometimes there are dances that require everybody's participation in order to complete them, but this is not the case in LD. It is however a necessary feature in GTD, leading to greater group cohesion as the rewarding element. Cohesion and anxiety are associated (Prapavessis & Carron, 1996). Athletes in teams with high cohesion exhibit low anxiety. Furthermore, in such cohesive teams, the psychological costs appear to be better moderated by this cohesion (Borrego et al., 2012). It is remarkable that participants in a cohesive group are connected with increased group efficacy, higher dissemination of responsibility among group members (Eys et al., 2003), and better mood (Eys et al., 2003; Lowthwe & Lane, 2002). The increase of group cohesion positively affects the entire team at once (Wolf et al., 2015). Group exercise with principles in cohesiveness has superior results in some parameters, like adherence,

than exercise in a standard exercise class which was not different from exercising at home with a contact (telephone calls) (Burke et al., 2006). Cohesion is considered an important ally of participants' exercise adherence (Spink & Carron, 1993).

In recreational team sports, the positive experiences of participants, like less pressure and better feelings, can promote adherence (Oh & Gill, 2017). In recreational activities, like dance, there is also less pressure and good mood. According to the data of the current study, both GTDs and LDs observed the same inclusion criterion, participating at least fifteen months in the specific dance class. Nevertheless, as it is presented in Table 2, GTDs participated in the specific dance programme much longer than fifteen months, something which did not occur for LDs. The characteristic of adherence is reinforced in GTD. Anxiety influences the degree of adherence (Hornik & Dulawa, 2019). Adherence might be in contrast with depression, anxiety and hostility (DiMatteo et al., 2000). For example, non-adherence in patients with diabetes is affirmed with higher anxiety levels when compared to adherents (Mendes et al., 2019). In the present study, the adherence in GTD is probably associated with lower anxiety levels.

Furthermore, listening to music is proposed for anxiety regulation through manipulation of stressful situations (Burns et al., 2002). Nevertheless, the type (classical or other) and the mode (major or minor) of music do not seem that have a vital role in the effects of music listening (Panteleeva et al., 2018). There are other processes, such as autobiographical memories, that are probably responsible for the beneficial effects of music in anxiety (Belfi et al., 2016). As a result, music which was used in LD did not bring about memories in the participants to connect with anxiety reduction. On the contrary, music in GTD appears to connect participants with previous circumstances, even if the participants in the present study were young adults (less than thirty-five years old).

We also detected that LDs had higher anxiety scores than both GTDs and sedentary participants. Sedentary lifestyle relates to high levels of anxiety and anxiety symptoms (Techenne & Hinkley, 2016; Vancampfort et al., 2018). Nevertheless, LDs presented higher levels of anxiety than sedentary participants. Furthermore, GTD is connected with lower levels of trait anxiety than LD. Trait anxiety is a personality feature (Spielberger, 1983) that is difficult to change and is more of a personality characteristic (Tian, 2016). Consequently, the current study points out that GTD is linked to people with less anxious personalities than LD; of course, further research is needed. One more significant result is that participants with sedentary lifestyle had significantly lower amount of PA than all the other teams, while the other three teams (GTD, LD and GEs) had no significant PA differences. These results suggest that the differences about anxiety are not due to the amount of PA.

Despite the extremely positive benefits of regular PA on physical and psychological health (Antunes et al., 2006; Rebar et al., 2015), many people are not engaging in any PA and lead a sedentary life (Esenturk et al., 2016). Dance and specifically GTD could be an alternative form of PA that young people can get involved in in a pleasurable and enjoyable way (Jago et al., 2016) while simultaneously promoting mental health through low levels of anxiety, one of the most serious mental health disorders.

Disclosure statement

The authors declare that there is no conflict of interest.

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RAZLIKE U ANKSIOZNOSTI KAO OSOBINI LIČNOSTI KOD UČESNIKA RAZLIČITIH VRSTA PLESA I GRUPNOG VJEŽBANJA

SAŽETAK

Anksioznost je glavni faktor rizika koji je povezan sa poremećajima mentalnog zdravlja širom svijeta. Grupno vježbanje se koristi za kontrolu anksioznosti. Ples je grupna fizička aktivnost (PA) koja pruža zadovoljstvo te ima pozitivnu vezu sa mentalnim zdravljem, a negativnu sa anksioznosti. Ova studija je ispitala razlike u anksioznosti kao osobini ličnosti kod mladih odraslih osoba (n = 200) u dobi od 25 do 34 godine, a koji su učestvovali u različitim grupama: a) grčki tradicionalni ples, b) latinski ples, c) programi grupnog vježbanja, i d) sjedilački način života, te je koncipirana kao transverzalna studija. Upitnik anksioznosti kao stanja i osobine ličnosti je korišten za procjenu anksioznosti kao osobine ličnosti, a skala aktivnosti u slobodnom vremenu je korištena za procjenu nivoa fizičke aktivnosti učesnika. Jednostruka analiza varijanse (ANOVA) je otkrila i) više nivoe anksioznosti kod plesača latinskog plesa u odnosu na one koji su se bavili grčkim tradicionalnim plesom (srednja razlika (MD = 7,39, p < ,001)) i ii) značajno najniži nivo fizičke aktivnosti u grupi koja vodi sjedilački način života, a u odnosu na sve druge grupe. Prema tome, ples, i to pretežno grčki tradicionalni ples, ima pozitivnu vezu sa anksioznosti koja se ispoljava kao osobina ličnosti i mentalnim zdravljem.

Ključne riječi: pridržavanje, odrasli, fizička aktivnost, anksioznost kao osobina ličnosti

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VARIATIONS OF THE SELECTED HAEMATOLOGICAL VARIABLES AND AEROBIC CAPACITY WITH ACUTE MODERATE ALTITUDE EXPOSURE

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ABSTRACT

The present investigation is proposed to ascertain the variations in synthesis and release of the selected haematological parameters and aerobic capacity with moderate altitude exposure. For this purpose, fifteen male handball players from Annamalai University were selected as subjects during their competitive season. The selected dependent variables, namely: erythropoietin (Epo), red blood cells (RBC), haemoglobin (Hb), haematocrit (Hct), and VO_2max, were appraised using procedures and instruments of scientific standards at sea level and during the sixth hour of acute exposure to moderate altitude. To statistically compare the changes of the selected haematological parameters and aerobic capacity at moderate altitude with that of the sea level, a paired t-test was used. Data analysis revealed that there is a significant amplification of Epo, RBC, Hb, and Hct, whereas VO_2max is significantly dwindling in response to moderate altitude exposure, since the obtained ' t ' ratios of 11.233, 13.284, 9.122, 7.682, and 8.605, respectively, were greater than the required table value of 2.145. Exposure to moderate altitude had an affirmative impact of 22.2%, 10.1%, 8%, and 6.3% on Epo, RBC, Hb, and Hct, respectively, whilst VO_2max is dwindled by 21.8%. These results suggest that acute exposure to moderate altitude induces significant changes of the selected haematological parameters, which requires abundant time for acclimatisation.

Keywords: moderate altitude, erythropoietin, red blood cells, haemoglobin, haematocrit, VO_2max

INTRODUCTION

Modern handball game demands both aerobic and anaerobic capacity for a player to demonstrate greater performance (Boraczyński & Urniaz, 2008; Delamarche et al., 1987). This game is filled with quick intermittent repeated sprints that demand greater aerobic capacity determining the result of the match. It is also established that players with greater aerobic capacity will tend to have a lower decline in power output and also take less mean sprint time to complete their repeated sprint (Chittibabu 2014a; Chittibabu 2014b). So, each player seeks a competitive advantage, since they undergo

numerous things that happen to bring changes in their environment throughout their sports career. In the formative years, the most common changes involve long, tiring journeys, sometimes combined with a stay for a number of days in an unfamiliar place. Later in the athlete's career there are more serious changes to take note of, and to prepare for. There are three environmental conditions which an athlete will have to learn how to acclimatise to. These are altitude, temperature and time change. Altitude is the most challenging of the ambient conditions.

At higher altitudes, the majority of them will experience some sort of uneasiness, even though at absolute rest. Performing physical activity at moderate and high altitudes can be more taxing.

The human body requires a continuous supply of oxygen to the tissues to maintain the process of metabolism. The source of this oxygen is the ambient air where the percentage of oxygen remains fixed at 20.93% regardless of altitude. Ascent to a higher altitude causes a reduction in barometric pressure, which induces a corresponding decrease in the partial pressure of oxygen in the inhaled air. Decreased availability of oxygen in the ambient air is the only environmental stress unique to high terrestrial altitude. It lowers the oxygen supply to body tissues, which causes altitude illness and the decline in physical and mental performance.

When the body is subjected to a hypoxic environment, adaptive processes attempt to facilitate the intake, transport and use of oxygen. Each adjustment to a higher altitude is progressive and requires time (Boning, 1997). Acclimatisation to high altitude includes a number of physiological and haematological adaptations that theoretically should improve O_2 transport to skeletal muscle during exercise (Levine & Stray-Gundersen, 1995).

Reduced arterial PO_2 at an altitude stimulates an increase in the total number of red blood cells, a condition termed polycythaemia. The erythrocyte-stimulating hormone erythropoietin (Epo), synthesised and released primarily from the kidneys in response to localised arterial hypoxia, initiates red blood cell formation within 15 hours after altitude ascent. In the weeks that follow, erythrocyte production in the marrow of the long bones increases considerably and remains elevated throughout the altitude stay (Groves et al., 1987). Valuable increases in haemoglobin also occur in proportion to the increased erythrocyte production. Up to a point, the more blood cells an athlete have, the more oxygen he can deliver to his muscles. The increased red blood cells, resulting in higher haemoglobin values, ensure better working capacity. The higher the altitude, the greater the stimulus will be to produce extra red cells. But, the upper limit of altitude is set by the side effects of altitude exposure. There are also a number of other changes that happen during acclimatisation, which may help athletic performance. At moderate altitudes of 2100 metres, this acclimatisation may take about two weeks. For higher altitudes, acclimatisation will take several weeks.

During early hypoxic exposure, an acute decrease in plasma volume occurs primarily due to increased dieresis. This decrease in plasma volume leads to a corresponding increase in haematocrit and haemoglobin. Haematocrit will continue to rise during the early days of altitude exposure.

Altitude has the greatest effect on endurance events, rather than anaerobic activities. The main reason for lessened endurance performance at an altitude is that it is a consequence of the lowered partial pressure of oxygen (PO_2). The purpose of this investigation is to determine the variation in synthesis and release of the selected haematological parameters and aerobic capacity with moderate altitude exposure.

METHODOLOGY

Subjects and variables

To determine whether there was any significant fluctuation in aerobic power and haematological parameters during acute exposure to moderate altitude, fifteen (15) male handball players from Annamalai University volunteered as subjects participating in the expedition to Ootacamund, an altitude of 2,200 metres above the mean sea level. The age and weight of the selected subjects amounted to

21.80 ± 2.01 years and 64.9 ± 5.2 kg, respectively, and they were recruited for the purpose of the study with their written informed consent. The independent variables considered in this study were (i) Sea Level (Chidambaram), 5.75 metres above the mean sea level and (ii) Moderate Altitude (Ootacamund), 2,200 metres above the mean sea level. The selected dependent variables, namely: erythropoietin (Epo), red blood cells (RBC), haemoglobin (Hb), haematocrit (Hct), and VO_2max, were assessed using calibrated and standardised instruments and procedures at sea level and during the sixth hour of acute exposure to moderate altitude. Standard solutions and chemicals were used for the blood test. Furthermore, the instruments involved in the blood test conformed to the scientific standard. The catalogue of dependent variables and the tests used are presented in Table 1.

The initial test was carried out the day before departure at Annamalai University, Chidambaram (5.75 m above MSL). The second test was conducted after an overnight

stay at Ootacamund (2,200 m above MSL) for six (6) hours. The collection of data was carried out at 06.00 hours at both the venues to avoid diurnal variations.

Blood sample collection

The subjects were weighed in kilograms and then blood is drawn from the antecubital vein by using a syringe. An elastic band is placed around the upper arm to apply pressure and cause the vein to swell with blood. The puncture site is cleaned with antiseptic, a needle is inserted into a vein and blood is withdrawn. During the procedure, the band is removed to restore circulation. Once the 5 mL blood has been collected, the needle is removed, and the puncture site is covered with cotton to stop bleeding. Part of the freshly collected blood specimen is transferred quickly to an airtight vial coated with K3 EDTA as an anticoagulant to stop it from clotting, and the rest of the specimen is placed in a vial without an anticoagulant.

Table 1: dependent variables

Sl. No.	Variables	Sample	Kits/Instruments	Units of Measurement
1.	Erythropoietin	Serum	DEP00 Quantikine IVD of R & D Systems Inc., Minneapolis, USA	mIU/mL
2.	Red Blood Cells	Blood	Automated Cell Counter	10^6/µL
3.	Haemoglobin			g/dL
4.	Haematocrit			%
5.	VO_2max		One-Mile Run	ml/kg/min

The specimens were transported either to the Laboratory, Division of Biochemistry, Annamalai University, Chidambaram or JSS College of Pharmacy, Ootacamund, where the specimens are processed for RBC, Hb and Hct by an automated cell counter (Sysmex, Japan). Furthermore, the serum was separated from the clotted blood specimen with centrifuge at 760 x g* for 15 minutes at room temperature to estimate the Epo concentration using the R & D Systems kit DEP00 Quantikine IVD Epo ELISA.

One-mile run test

The one-mile run test was administered to assess the aerobic capacity of the subjects. The time taken to cover the distance of one-mile was recorded in minutes along with the pulse rate at the end of the run. The algorithms to calculate VO_2max is:

VO_2max = 108.844 - 0.1636W - 1.438T - 0.1928H

The pulse rate was estimated from a sitting position using the oscillometric method with the help of the digital sphygmomanometer.

The moderate altitude VO_2max computed for every subject from the performance of 1-mile run was adjusted for the difference in partial pressure of oxygen at moderate altitude. The formula for ascertaining the partial pressure of inspired oxygen as prescribed by Bert (1878) is as follows:

Tracheal PO_2 = (Pbar – 47) 20.94 x 100^{-1}

PO2 = partial pressure of oxygen.

Pbar = barometric pressure.

Where, PO_2 is assumed to be 20.94% of dry air, and inspired gas is saturated with water vapour.

Experimental design and statistical techniques

The random group design involving fifteen subjects was used for the purpose of expounding the acute alterations of the selected haematological variables and aerobic capacity in response to the decreased partial pressure of inspired oxygen with moderate altitude exposure. To determine the significant difference existing between the data collected at sea level and moderate altitude on the selected dependent variables, a paired t-test was used. The level of significance was accepted at $P < 0.05$.

RESULTS

The descriptive analysis and t-test of the data collected on the selected haematological variables and aerobic capacity at sea level and moderate altitude is presented in Table 2.

Table 2: computation of data on the selected haematological variables at sea level and moderate altitude

Variables	Location	N	Mean	SD	't' ratio
Erythropoietin	Sea level	15	7.38	1.472	11.23*
	Moderate Altitude	15	9.02	1.645	
Red Blood Cells	Sea level	15	4.772	0.296	13.28*
	Moderate Altitude	15	5.256	0.213	
Haemoglobin	Sea level	15	14.50	0.859	9.12*
	Moderate Altitude	15	15.66	0.689	
Haematocrit	Sea level	15	44.26	2.313	7.68*
	Moderate Altitude	15	47.06	2.080	
VO_2max	Sea level	15	63.502	4.454	8.60*
	Moderate Altitude	15	49.635	3.807	

* $p < 0.05$

DISCUSSION

The findings of the study show that there is a significant amplification of Epo, RBC, Hb, and Hct, whereas there is a significant dwindling of VO_2max in response to moderate altitude exposure, since the obtained ' t ' ratios of 11.233, 13.284, 9.122, 7.682, and 8.605, respectively, were greater than the required table value of 2.145. Thus, the findings of the study reveal that there was a significant alteration of Epo, RBC, Hb, Hct, and VO_2max by 22.2%, 10.1%, 8%, 6.3%, and 21.8% respectively.

From the investigation, it has been empirical that RBC of sea level inhabitants have been increased comprehensively with moderate altitude exposure, which is in conformity with the statement of Sawka et al., (2000); Hannon et al., (1969) and Alexander et al., (1967) that the decrease in plasma volume occurring within several hours of altitude exposure increases red blood cell concentration, and Groves et al., (1987) pronounced that erythropoietin synthesises and releases in response to hypoxia, and initiates red blood cell formation within 15 hours after altitude ascent. In the weeks that follow, erythrocyte production increases considerably and remains elevated throughout the altitude stay. Fried, Johnson and Heller (1970); Jelkmann (1982) and Seferynska et al., (1989) stated that the major increase in the concentration of red blood cells occurs only after the decline in plasma erythropoietin secretion.

Furthermore, the results show that the Hb of sea level inhabitants have been increased comprehensively with moderate altitude exposure, which is in line with the study of Alexander et al., (1967) that shows an increase in haemoglobin as a result of the decrease in plasma volume with a week stay at 4300 m. Berlin, Reynafarje and Lawrence (1954) pronounced that the haemoglobin increase observed in the first two days is due to the decreased plasma volume resulting from extravascular fluid shifts rather than increased red cell mass. Schuler et al., (2007); Stray-Gundersen, Chapman & Levine (2001); Boning (1997), and Ingjer & Myhre (1992) found that Hb concentration increased significantly during altitude exposure.

It has been found that the Hct of sea level inhabitants have increased comprehensively with moderate altitude exposure, and this finding is in agreement with the observation of Heinicke et al., (2003) that Hct increased with the elevation in altitude.

Furthermore, the Epo of sea level inhabitants have been increased comprehensively with moderate altitude exposure, which is in agreement with the findings of Gunga et al., (2003) and Stray-Gundersen, Chapman and Levine (2001) that erythropoietin concentration almost doubled after one night at moderate altitude, while Boning et al., (2004) stated that Epo was a little increased in a moderate altitude of 2600 m. Gunga et al., (1994) quoted that Epo concentrations showed a remarkable increase 48 hr after the ascent. Heinicke et al., (2005) affirmed that plasma erythropoietin concentration increased up to day 4 at altitude. Richalet et al., (1994) pronounced that after an initial sharp increase in Epo, it decreased after two and three weeks.

The finding of the study also indicates that there is a significant decrement in VO_2max of sea level inhabitants with moderate altitude exposure; this observation is relevant to the studies of Schuler et al., (2007); Calbet et al., (2002); Fulco et al., (1998); Robergs et al., (1998); Boning (1997); Cymerman et al., (1989); Boutellier et al., (1983), and Saltin et al., (1968) that observed a decrement in VO_2max with increasing altitude. Furthermore, the observations of Faulkner et al., (1968); and Adams et al., (1975) state that medium altitude causes a performance decrement by an increase in run times for distances. The insignificance in the decrement might be owing to equatorial bulge (the high altitude barometric pressure at the equator is higher than elsewhere in the globe (Heath & Williams, 1995)) of the barometric pressure and the level of ascent for the sojourn at moderate altitude.

CONCLUSIONS

The present exploration displays that acute exposure to moderate altitude induces significant changes of the selected haematological parameters to increase the oxygen transport capacity of the blood; however, aerobic capacity has been impinged consequent to the exposure to low level of partial oxygen pressure (PO_2). Thus, exposure to moderate altitude of 2200 metres necessitates an abundant period for acclimatisation.

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VARIJACIJE ODABRANIH HEMATOLOŠKIH VARIJABLI I AEROBNOG KAPACITETA UZ AKUTNO IZLAGANJE UMJERENOJ NADMORSKOJ VISINI

SAŽETAK

Ovo istraživanje je pokušalo utvrditi varijacije u sintezi i lučenju odabranih hematoloških parametara i aerobnog kapaciteta uz izlaganje umjerenoj nadmorskoj visini. U tu svrhu je odabrano petnaest rukometaša sa Annamalai univerziteta, a koji su u to vrijeme bili u takmičarskoj sezoni. Odabrane zavisne varijable, i to: eritropoetin (Epo), eritrociti (RBC), hemoglobin (Hb), hematokrit (HcT) i VO_2max, su ispitane korištenjem procedura i instrumenata koji ispunjavaju naučne standarde, na morskom nivou i tokom šestog sata akutnog izlaganja umjerenoj nadmorskoj visini. Za statističko poređenje promjena odabranih hematoloških parametara i aerobnog kapaciteta na umjerenoj nadmorskoj visini sa onim na morskom nivou korišten je t-test. Analiza podataka je otkrila postojanje značajnog povećanja Epo, RBC, Hb i Hct, dok se VO_2max značajno smanjio usljed izlaganja umjerenoj nadmorskoj visini obzirom da su dobijeni t-omjeri od 11,233, 13,284, 9,122, 7,682 i 8,605 bili veći od tablične vrijednosti u iznosu 2,145. Izlaganje umjerenoj nadmorskoj visini je pozitivni uticaj od 22,2%, 10,1%, 8% i 6,3% na Epo, RBC, Hb i Hct, dok se VO_2max smanjio za 21,8%. Ovi rezultati ukazuju da akutno izlaganje umjerenoj nadmorskoj visini prouzrokuje značajne promjene odabranih hematoloških parametara, što zahtijeva dosta vremena za prilagođavanje.

Ključne riječi: umjerena nadmorska visina, eritropoetin, eritrociti, hemoglobin, hematokrit, VO_2max

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RESEARCH ON PHYSICAL STRENGTH DEVELOPMENT OF HIGH SCHOOL MALE BADMINTON PLAYERS

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ABSTRACT

Physical strength is essential to the performance of badminton players. Therefore, it is especially important to pay attention to improving physical strength in teen players. This paper offers an approach to assess the physical strength development of male players in high school badminton clubs. We collected and studied data from both local and foreign research papers, combining interviews with experts, and hence worked out 5 tests on physical strength. The results demonstrate growth and make sense in terms of statistics in all tests. The 30-second crunches test particularly shows a growth rate w = 8.35%, higher than that of the other tests. The research results contribute to the basis of building assessment standards for the physical strength of high school male badminton players.

Keywords: physical strength, badminton, growth rate, high schools

INTRODUCTION

Sports and physical education at schools aim to maintain and improve students' health and physical strength in accordance with the required standards. Therefore, it is essential to equip students with basic theoretical knowledge about exercise practices, motor skills and basic techniques of some sports (Hollis et al., 2017). This helps to form a sense of discipline, collective spirit, and build a healthy lifestyle and self-discipline to exercise their bodies (Bechter et al., 2021). Meanwhile, schools should be facilitated to build and develop a strong and extensive sports movement (Mayorga et al., 2018; Kim et al., 2019; Kwon et al., 2018; Williams et al., 2020).

In Vietnam, school sports and physical education mainly aim to solve three problems. First, school physical education is associated with social moral education, building a collective spirit, a sense of discipline, trust, healthy active lifestyle, and self-discipline to exercise. Second, it is aimed to provide students with basic theoretical knowledge about physical training and sports, as well as motor skills and basic techniques for some appropriate sports. On that basis, they can foster their ability to use the means to exercise, actively participate in promoting and organising physical training and sports activities at schools and in the society. The last is the contribution to maintaining and improving students' health, improving their physical strength, developing a body of fitness, and meeting the prescribed physical standards (Hien, 2016; Nguyen, 2016).

Badminton was first developed in Britain in the late

19th century, and it soon expanded across the globe. In 1992, badminton was included as an official sport in the Summer Olympic Games by the World Olympic Committee (Laffaye et al., 2015). In Vietnam, this sport witnesses a slower development than others. In 1994, Vietnam Badminton Federation became an official member of the World Badminton Federation. Badminton is a popular sport that is favoured by many people. It is a non-direct combat sport whose results rely on such factors as technique, physical strength, tactics, and mental state of the players (Phomsoupha & Laffage, 2015; Lam et al., 2020). In doubles matches, it requires team coordination and the combination of above factors to win. Badminton competition is a non-cyclical activity in which the situations on the court constantly change between attack and defence. Techniques also vary among situations, such as smashing, serving, drop shot, lobbing, single-step, multi-step or jump moves, etc. (Lam et al., 2020). Playing badminton requires a comprehensive combination of speed, strength, endurance, flexibility, dexterity, and varied technique to constantly adapt to situations on the court. In the meantime, players also need the ability to judge and read situations of the match in order to take the initiative and get points (Robertson et al., 2021; Chau, 2020; Nezar et al., 2022). As a result, badminton helps players to develop comprehensively, strengthen their immune system, and hence it is suitable for people of various ages.

Badminton is one of the selected subjects in the physical education programmes of many Vietnamese high schools. This paper evaluates the professional physical development of players in Vietnamese high schools. Through the process of training tests and collecting actual data to check the reliability, we make assessments about the fitness development of high school students after a period of practice.

MATERIALS AND METHODS

We collected, synthesised and researched both local and foreign references (Hollis et al., 2017; Kwon et al., 2018; Le, 2014), in addition to consulting experts and coaches to determine some professional fitness assessments. We finally came up with exercises, including: 30-Second crunches, spot jump, moving to pick up 10 shuttlecocks at 4 corners, moving back and forth 10 times, and 2-minute jump rope. This method has been approved by 80% of experts and coaches. The subject of the study is male badminton players of high school age. The duration of the study was within 1 year.

30-Second crunches

The purpose of this exercise is to assess the players' speed and endurance. It is performed as follows: Lie down on your back, bend the knees with the feet held fixed by another person. The players lift their upper body and then return to the starting position with the shoulders held beyond the floor, which counts as a crunch. The players must do as many crunches as possible and do the exercise once. The result is the number of crunches done in 30 seconds.

Spot jump

The purpose of this exercise is to assess explosive power of the players' leg muscles. It is performed as follows: The players apply chalk on their hands, stand up straight, raise their arms straight up, lean against the wall with 3 touch points: outer side of the foot, hip and palm (mark the initial position). Then, they perform a spot jump by touching the palm to the wall (mark the 2nd position). The result is the jumping position minus the initial position. They perform 3 spot jumps and get the highest result.

Moving to pick up 10 shuttlecocks at 4 corners

The purpose of this exercise is to assess players' speed, speed power and speed endurance. When moving, it is essential to use the proper movement technique in badminton. It is performed as follows: The players stand in the middle of the court (0.5 m x 0.5 m), then move to pick up shuttlecocks at the position numbered from 1 to 4 on the court (Figure 1). They put shuttlecocks into the centre box and do it clockwise until the last shuttlecock is picked up. The result is the time needed to complete the task.

Moving back and forth 10 times

The purpose of this exercise is to assess players' speed. It is performed as follows: The players stand in the preparation position at the back of the court, move properly to the position close to the net, move back and forth continuously, and touch the specified position 10 times (Figure 2). The result is the time needed to complete the task.

Figure 1: Moving to pick up 10 shuttlecocks at 4 corners

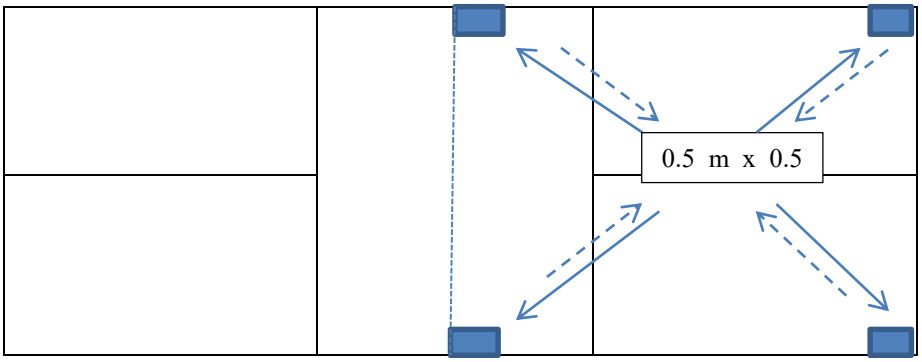

Figure 2: Moving back and forth

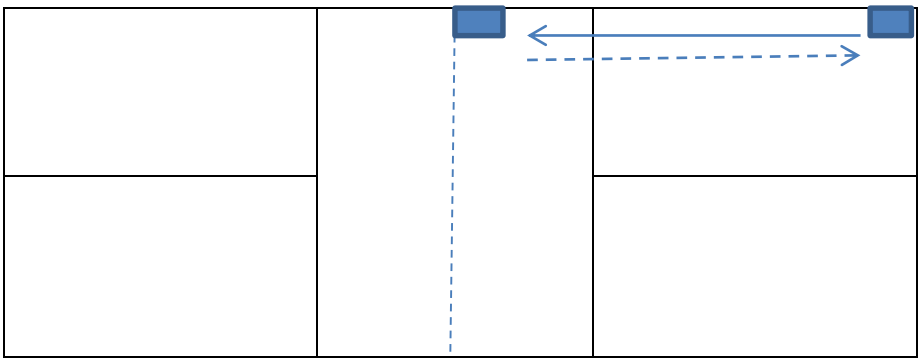

Table 1: The results of male badminton players' professional fitness development after one year of training

Test	Initial		After one year		w	t	P
	$\overline{X}$	S	$\overline{X}$	S			
30-Second crunches (times)	23.92	1.24	26.00	1.28	8.35	4.17	< 0.05
Spot jump (cm)	57.33	4.46	59.83	3.04	4.27	3.32	< 0.05
Moving to pick up 10 shuttlecocks at 4 corners (s)	26.58	1.93	25.33	1.37	**-4.82**	2.53	< 0.05
Moving back and forth 10 times (s)	37.17	2.52	35.75	2.05	**-3.89**	3.74	< 0.05
2-Minute jump rope (times)	228.33	13.58	237.92	5.38	4.11	3.19	< 0.05

2-Minute jump rope

The purpose of this exercise is to assess players' endurance and dexterity. It is performed as follows: The players hold both ends of the rope to jump continuously for 2 minutes and perform the task once. The result is the number of jumps in 2 minutes.

Statistical methods

The data collected during the research was processed and analysed by computational and statistical methods with the support of Excel software. The values taken for evaluation include mean ( ), standard deviation (**S**), growth rate (**w**), mean of two related samples (**t**), and difference (**P**) (Byshevets et al., 2019; Vveinhardt et al., 2020).

RESULTS

After synthesising data and selecting exercises to assess players' physical strength, we conducted interviews with experts and coaches. The exercises

approved by more than 80% of valid votes will be selected to evaluate the fitness of high school badminton players. Then, we tested the reliability and validity of the exercises. In the end, we selected 5 exercises to assess players' physical strength, including: 30-second crunches, spot jump, moving to pick up 10 shuttlecocks at 4 corners, moving back and forth 10 times, and 2-minute jump rope. The results of high school male badminton players' professional fitness development after one year of training are shown in Table 1.

After one year of training, all 5 out of 5 fitness tests for high school male badminton teams showed growth and were statistically significant at the probability value (**P** < 0.05). Through the statistical method, we calculated the indexes as shown in Table 1. With the value $\mathbf{t}_{standard}$ = 2.201, the specific results are as follows:

In the 30-second crunches exercise, after one year of training, with the growth rate **w** = 8.35%, as $\mathbf{t}_{calculated}$ = 4.17 > $\mathbf{t}_{standard}$ = 2.201, we can conclude this growth is statistically significant at the probability value **P** < 0.05.

In the spot jumping exercise, after one year of training, with the growth rate **w** = 4.27%, as $\mathbf{t}_{calculated}$ = 3.32 > $\mathbf{t}_{standard}$ = 2.201, we can conclude this growth is statistically significant at the probability value **P** < 0.05.

In the exercise consisting of moving to pick up 10 shuttlecocks at 4 corners, after one year of training, with the growth rate **w** = 4.82%, as $\mathbf{t}_{calculated}$ = 2.53 > $\mathbf{t}_{standard}$ = 2.201, we can conclude this growth is statistically significant at the probability value **P** < 0.05.

In the exercise consisting of moving back and forth 10 times, after one year of training, with the growth rate **w** = 3.89%, as $\mathbf{t}_{calculated}$ = 3.74 > $\mathbf{t}_{standard}$ = 2.201, we can conclude this growth is statistically significant at the probability value **P** < 0.05.

In the 2-minute jump rope exercise, after one year of training, with the growth rate **w** = 4.11%, do $\mathbf{t}_{calculated}$ = 3.19 > $\mathbf{t}_{standard}$ = 2.201, we can conclude this growth is statistically significant at the probability value **P** < 0.05.

DISCUSSION

As demonstrated in the results, after one year of practice, all 5 tests show a statistically significant growth. The 30-second crunches exercise shows the highest growth, with the growth rate **w** = 8.35%, and it is higher than that of the other tests (which get the growth rates of 3-4%). This is explained by the fact that male players should have faster development in the abdominal muscles, especially during high school age. The exercise of doing crunches requires a lot of endurance and strength of the abdominal muscles. After a year of training, the health and endurance of the players has improved significantly.

Through interviews with experts, Nguyen et al. (2018) gave out 5 tests to assess the physical strength of female badminton players, including long jumping, moving around 4 corners of the court, standing in place and throwing shuttlecocks, as well as moving back and forth 5 times, and jumping rope in 30 seconds. These are similar to ours tests of moving to pick up shuttlecocks, moving back and forth and jumping rope. However, our study selected the test of spot jumping and doing crunches in 30 seconds with higher rating from experts. Our exercises are selected with a longer duration or higher number of repetitions to accommodate male players. The research results are all at the statistical probability with high confidence.

Badminton can be considered as a strategy to improve health and fitness for high school students (Patterson et al., 2017). In fact, badminton does not get enough attention and serious consideration in Vietnam. This is also the reason why badminton in Vietnam is less developed than in other countries. To the majority of players, this sport is easy to play, easy to practice, with little direct contact or confrontation, but can still improve health and motor skills. From this study, we hope that badminton will become more interesting and developed in high schools, while schools need to focus on the resources of teachers, coaches and facilities to improve the quality of training this sport.

To sum up, through playing badminton at high school ages, the physical strength of the male students has been improved remarkably. All tests showed a significant growth, with the highest belonging to the 30-second crunches test. As amateur players, their practice struggled with certain difficulties. Therefore, we need to increase the number of training sessions and reduce the number of students in a class in order to improve the physical strength of high school male students. If so, the integration of physical exercises into the new curriculum will be more effective. This also concurs with previous studies (Patterson et al., 2017; Chng et al., 2019).

CONCLUSION

This paper gave out 5 tests of physical strength for male badminton players at high school ages. After one year of practice, the results show a statistically significant growth in all tests. They are of the basis to build assessment standards for the physical strength of male badminton players in high schools. From this study, we hope that badminton will become more

interesting and developed in high schools, while schools need to focus on the resources of teachers, coaches and facilities to improve the quality of training this sport.

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ISTRAŽIVANJE RAZVOJA FIZIČKE SNAGE KOD IGRAČA BADMINTONA SREDNJOŠKOLSKE DOBI

SAŽETAK

Fizička snaga je ključna za učinkovitost igrača badmintona. Prema tome, iznimno je važno da se pažnja posveti razvoju fizičke snage kod igrača adolescentske dobi. Ovaj rad nudi pristup za procjenu razvoja fizičke snage igrača badmintona koji treniraju u badminton klubovima srednjih škola. Prikupili smo i proučili podatke lokalnih i inozemnih istraživanja uz intervjue održane sa stručnjacima te došli do 5 testova fizičke snage. Rezultati pokazuju porast i smisleni su po pitanju statistike za sve testove. Test trbušnjaci - 30 sekundi posebno pokazuje stopu porasta w = 8,35%, a koja je viša od onih dobijenih za druge testove. Rezultati istraživanja doprinose osnovi za izgradnju standarda za procjenu fizičke snage igrača badmintona srednjoškolske dobi.

Ključne riječi: fizička snaga, badminton, stopa porasta, srednje škole

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THE RELATIONSHIP BETWEEN MOTOR SKILLS OF STUDENTS WITH A COCHLEAR IMPLANT OF DIFFERENT AETIOLOGIES OF HEARING IMPAIRMENT, AGE AT ONSET OF HEARING IMPAIRMENT AND AGE OF COCHLEAR IMPLANT PLACEMENT

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ABSTRACT

Introduction: Hearing impairment is one of the most common congenital impairments. It not only results in the child's inability to communicate with the world, but also significantly affects the child's emotional, social and motor development. To date, research on motor development in children with cochlear implants has been limited, with balance being the most common research topic. Merely a few studies have addressed some of the many aspects of motor skills in children with cochlear implants. **Objective:** The aim of this study was to examine the relationship between motor skills of students with cochlear implants of different aetiologies of hearing impairment, age at onset of hearing impairment and age at cochlear implant (CI) placement. **Methods:** The study included a total of 70 male and female students, aged 6 to 18 years, enrolled in a regular elementary or high school. The Bruininks-Oseretsky Test of Motor Proficiency, second edition, was used to determine the motor skills of the students. Using Spearman's rank correlation, we compared the Bruininks-Oseretsky Test of Motor Proficiency scores with the child's age at onset of hearing impairment and the child's age at CI placement. **Results:** The results of the study showed that age at onset of hearing impairment was not significantly correlated with the level of motor skills. However, age at CI placement correlated significantly with manual dexterity, balance, upper-limb coordination, and strength, but only in subjects with acquired hearing impairment, i.e., subjects with

acquired hearing impairment who underwent implantation later in life performed significantly better. **Conclusion:** Age at CI placement has differential effects on motor skills due to different aetiologies of hearing impairment in students with cochlear implants.

Keywords: cochlear implant, motor skills, aetiology of hearing impairment

INTRODUCTION

Hearing impairment is one of the most common congenital impairments and occurs in an average of 1 to 3 children per 1,000 newborns (Van Naarden, Decouflé, & Caldwell, 1999; Niskar et al., 1998). In 70% to 80% of children, the impairment is present at discharge from the maternity ward, and in 20% to 30%, the impairment occurs postpartum, most often due to certain diseases or traumatic head injury (Fonseca et al., 1999; Davis et al., 1997; Kittrell & Arjmand, 1997). Hearing impairment not only results in the child's inability to communicate with the world, but also has a significant impact on the child's emotional, social and motor development (Marn, 2005; Rajendran, Roy, & Jeevanantham, 2012). Most previous studies have examined the differences in motor skills between hearing-impaired children without hearing aids (cochlear implants) and children without hearing impairment and found that hearing-impaired children perform significantly worse on motor skills tests, particularly in relation to balance (Rine et al., 1996; de Souza Melo et al., 2012; Suarez et al., 2007; Winnick & Short, 1986; Shall, 2009, adapted from Vidranski & Farkaš, 2015). A somewhat smaller number of previous studies examined differences primarily in balance and somewhat less frequently in other motor skills between children with cochlear implants, children with hearing impairment without cochlear implants and children without hearing impairment. Motor skills outcomes were significantly worse in children with cochlear implants than in others (Cushing et al., 2008; Ebrahimi, Movallali, Jamshidi, Haghgoo, & Rahgozar, 2016; Kelly et al., 2018; Kluenter, Lang-Roth, Beutner, Hüttenbrink, & Guntinas-Lichius, 2010; Jernice & Nonis, 2011; Livingstone & Mcphillips, 2011; Schlumberger, Narbona & Manrique, 2004). Some researchers have linked observed deficits in motor skills in children with cochlear implants to damage to the vestibular apparatus (Rajendran, 2012; Cushing, Papsin, Rutka, James, & Gordon, 2008). However, in a study by Wiszomirska et al. (2019), no differences were found between hearing-impaired children with and without vestibular impairment, suggesting that balance disorders may also occur in hearing-impaired individuals who do not have an associated vestibular impairment. A review of previous research indicates that children with hearing impairment and CI differ significantly from children without hearing impairment. However, the effects of age at onset of hearing impairment and age at CI placement on children's motor skills have not been extensively studied (Cushing et al., 2008; Gheysen et al., 2008). For a child to become a healthy adult, harmonious intellectual, emotional, social, and motor development is required. Therefore, this paper aimed to contribute to the observation of the influence of different factors (age at onset of hearing impairment and age at CI placement) on the development of motor skills in children with CI.

Objectives and research hypotheses

The aim of this study was to analyse the relationship between motor skills of students with CI, with hearing impairment of different aetiologies, age at onset of hearing impairment and age at which the CI was inserted. H1.1. There is a statistically significant correlation between the motor skills of subjects with CI of different aetiologies regarding the onset of hearing impairment. H1.2. There is a statistically significant correlation between the motor skills of subjects with CI of different aetiologies regarding their age at the implant placement.

MATERIALS AND METHODS

Participants

The study included a total of 70 male and female students aged 6 to 18 years from all regions of the Republic of Croatia (RH), who are enrolled in an elementary or high school in the Republic of Croatia. Information (first and last names, contacts) on subjects with cochlear implants was obtained from the Sisters of Charity Hospital, the Croatian reference centre for CI placement. The company for purchasing CI is Media d.o.o. (Ltd.). The subjects with CI were divided into two subgroups according to the aetiology of their hearing impairment. The first group (n1 = 33) consisted of subjects with acquired hearing impairment (CiS), and the second group (n2 = 37) consisted of subjects with congenital hearing impairment (CiU). The inclusion criteria were that the subjects attended an elementary or high school with an individualised or adapted curriculum, had no associated visual impairment, musculoskeletal impairment, and no associated neurological disease.

Variables

The Bruininks-Oseretsky Test of Motor Proficiency, second edition, (BOT™-2) was used to assess motor skills. This instrument is used to assess a wide range of motor skills and to diagnose deficits in motor development (from mild to moderate), as well as to assess the motor skills of individuals with developmental disabilities. It was developed to assess the motor skills of a wide age range, i.e., from 4 to 21 years of age (this study included subjects from 6 to 18 years old). The Bruininks-Oseretsky Test of Motor Proficiency is a test battery with a total of 54 tests used to assess fine and gross motor skills. Fine motor skills are assessed using four factors: fine motor precision (FMP), fine motor integration (FMI), manual dexterity (MD), and upper-limb coordination (ULC). Gross motor skills are also assessed using four factors: bilateral coordination (BC), balance (B), running speed and agility (RSA), and strength (S). The test has excellent measurement properties; the internal consistency for assessing reliability (Cronbach's α) is 0.99, and the interclass correlation coefficients (ICC) are 0.80 – 0.99 (Griffiths, Toovey, Morgan & Spittle, 2018).

Measurement protocol

The original results for each task within each factor were evaluated using the task sheets and according to the instructions of the instrument BOT™-2. Permission to conduct the research was obtained from the Ministry of Science, Education, and Sport. The test was carried out by kinesiologists who had previously been educated and trained to carry out the test using the BOT™-2 instrument.

Statistical data processing

Statistical data processing for motor skill variables was performed with the package STATISTICA, statistical software package version 12 (www.statsoft.com.StatSoft, Inc. Tulsa, OK, USA). The basic descriptive parameters and the normality of the results distribution for all quantitative variables used in the study were calculated using the Kolmogorov-Smirnov test. Since none of the variables were normally distributed, nonparametric tests were used to analyse the variables. The correlation between the scores on the BOT™-2 scales, age at onset of hearing impairment and age at CI placement was determined. The correlation of scores on the BOT™-2 scales with age at onset of hearing impairment and age at CI placement was tested for the entire group and individual groups by aetiology of hearing impairment using Spearman's rank correlation. The results of all tests with $p < 0.05$ are considered statistically significant and are presented.

RESEARCH RESULTS

The study included a total of 70 subjects with CI. Parents cited unknown causes (n: 10) and meningitis (n: 9) as the most common causes of hearing impairment in subjects with acquired hearing impairment, while perinatal disorders (n: 7), ear infections (n: 5), therapy (n: 1), and genetic causes (n: 1) were cited as less common causes. In subjects with congenital hearing impairment, genetic disorders were the most common cause (n: 28), while unknown causes (n: 6) were cited less frequently, and cytomegalovirus (n: 2) and other intrauterine diseases (n: 1) were cited quite rarely (Table 1). Due to the large dispersion in the aetiology of hearing impairment, the number of subjects within each aetiology group would be too small, so subjects were divided into two groups by aetiology – subjects with acquired hearing impairment (CiS) and subjects with congenital hearing impairment (CiU). Subjects with CI were further divided into two groups considering the aetiology of hearing impairment – acquired hearing impairment (n: 33) and congenital hearing impairment (n: 37).

Table 1. The aetiology of hearing impairment

THE AETIOLOGY OF HEARING IMPAIRMENT	CiS	CiU
Genetic disorders	1	28
Unknown	10	6
Meningitis	9	-
Intrauterine diseases	-	3
Perinatal diseases	7	-
Ear infections	5	-
Therapy	1	-

Note: CiS – subjects with acquired hearing impairment, CiU – subjects with congenital hearing impairment

Age at onset of hearing impairment is shown in Table 2. The average age at onset of hearing impairment in subjects with acquired hearing impairment is 9.28 months. For the largest number of these subjects, 13 out of 33, the hearing loss occurred in the first month of life, for nine students, it occurred in the twelfth month of life, for five of them, it occurred in the third month, for four, it occurred in the ninth month, for one student, it occurred in the fourth month of life, and for one, it occurred in the third year of life.

Table 2. Age at onset of hearing impairment

Age at onset of hearing impairment	**CiS**	**CiU**
0 years	0	37
1 month	13	-
3 months	5	-
4 months	1	-
9 months	4	-
12 months	9	-
36 months	1	-
Average age at onset of hearing impairment	9.28	0

Note: *in months; CiS – subjects with acquired hearing impairment, CiU – subjects with congenital hearing impairment

Table 3. shows that the majority of subjects received the CI between one and two years of age (n: 29). Slightly fewer subjects underwent cochlear implantation between the ages of two and three (n: 16), seven subjects received the CI between the ages of three and four, eight between the ages of four and five, three subjects between the ages of five and six, two subjects between the ages of six and seven, while only a few subjects received the CI at later age. The average age of cochlear implantation in subjects with acquired hearing impairment is three years and nine months, while it is two years and nine months in subjects with congenital hearing impairment.

Table 3. Age at cochlear implantation

AGE AT COCHLEAR IMPLANTATION	**CiS**	**CiU**	**TOTAL**
1 year and 1 month	2	0	2
1 year and 4 months	0	2	2
1 year and 5 months	0	1	1
1 year and 6 months	0	1	1
1 year and 8 months	1	2	3
1 year and 9 months	2	0	2
1 year and 11 months	3	1	4
2 years	4	10	14
TOTAL	12	17	29
2 years and 1 month	0	1	1
2 years and 3 months	0	1	1
2 years and 5 months	1	1	2
2 years and 6 months	1	2	3
2 years and 7 months	1	0	1

2 years and 8 months	0	1	1
2 years and 11 months	1	0	1
3 years	3	3	6
TOTAL	7	9	16
3 years and 1 month	0	1	1
3 years and 2 months	1	0	1
3 years and 3 months	0	1	1
3 years and 5 months	0	1	1
3 years and 6 months	1	1	2
3 years and 11 months	0	1	1
TOTAL	2	5	7
4 years and 1 month	0	1	1
4 years and 3 months	1	0	1
4 years and 5 months	1	0	1
4 years and 8 months	0	1	1
4 years and 11 months	2	0	2
5 years	2	0	2
TOTAL	6	2	8
5 years and 3 months	0	1	1
6 years	1	1	2
TOTAL	1	2	3
6 years and 11 months	1	0	1
7 years	0	1	1
TOTAL	1	1	2
7 years and 7 months	1	0	1
9 years	1	1	2
12 years and 4 months	1	0	1
14 years and 2 months	1	0	1
TOTAL	33	37	70
Average age	3.91	2.90	

Note: CiS – subjects with acquired hearing impairment, CiU – subjects with congenital hearing impairment

Motor skills of students with CI, with hearing impairment of different aetiologies considering the age at onset of hearing impairment and age at CI placement

The mean age at onset of the acquired hearing impairment is 9.28 months, while in subjects with congenital hearing impairment, it was present at birth. The Spearman's rank correlation was performed to determine the correlation of scores in BOT™-2 factors with the age at onset of hearing impairment. Table 4 shows that no significant correlation was found between age at onset of hearing impairment and the measured BOT™-2 factors (Table 4).

Table 4. Correlation of the results of the BOT™-2 factors with age at onset of hearing impairment

FACTORS	SUBJECTS	N	R	p
FMP	CiS	33	0.302	0.088
FMI	CiS	33	0.212	0.236
MD	CiS	33	0.285	0.108
BC	CiS	33	0.156	0.386
B	CiS	33	0.208	0.246
RSA	CiS	33	0.296	0.095
ULC	CiS	33	0.283	0.110
S	CiS	33	0.238	0.182

Note: CiS – subjects with acquired hearing impairment, N – number of subjects in a group, R – Spearman's correlation coefficient, FMP – fine motor precision, FMI – fine motor integration, MD – manual dexterity, BC – bilateral coordination, B – balance, RSA – running speed and agility, ULC – upper-limb coordination, S – strength.

Furthermore, descriptive indicators of age at cochlear implantation show that subjects with congenital hearing impairment received CI slightly earlier than subjects with acquired hearing impairment (Table 5). In subjects with congenital hearing impairment, CI were placed at an average age of 2.9 years, while in subjects with acquired hearing impairment, CI were placed on average age of 3.9 years.

Table 5. Descriptive indicators for subjects with acquired and congenital hearing impairment for age at CI placement

VARIABLES	SUBJECTS	N	M	SD	Min	Max
AGE AT COCHLEAR IMPLANT PLACEMENT	CiS	32	3.91	3.14	1.10	14.20
AGE AT COCHLEAR IMPLANT PLACEMENT	CiU	37	2.90	1.66	1.11	9.00

Note: N – number of subjects, M – mean, SD – standard deviation, Min – minimum value, Max – maximum value, CiS – subjects with acquired hearing impairment, CiU – subjects with congenital hearing impairment

For motor skills of subjects with CI of different aetiology of hearing impairment with respect to age at CI placement, the correlation of BOT™-2 factor scores with the age at CI placement was also examined (Table 6). In the total sample of subjects, no correlation of the results with any of the measured factors was found. However, when the relationship between the BOT™-2 factor scores and subjects with acquired hearing impairment and the relationship between the BOT™-2 factor scores and subjects with congenital hearing impairment were examined separately, the following was found: for students with acquired hearing impairment, age of implantation was significantly related to certain BOT™-2 factors – manual dexterity (MD), balance (B), upper-limb coordination (ULC), and strength (S), while no significance was found for fine motor skills precision (FMP), fine motor skills (FMI), bilateral limb coordination (BC), and running speed and agility (RSA). In other words, the later the age of cochlear implantation, the better the results in the observed factors. In contrast to this group, no significant correlation of BOT™-2 factors with implantation age was observed in subjects with congenital impairment (Table 6).

Table 6. Correlation of scores on BOT™-2 factors with age at cochlear implantation in subjects with different aetiologies of hearing impairment

FACTORS	SUBJECTS	N	R	p
FMP	CiS	32	0.341	0.056
FMI	CiS	32	0.246	0.175
MD	CiS	32	0.360	0.043
BC	CiS	32	0.227	0.211
B	CiS	32	0.407	0.021
RSA	CiS	32	0.259	0.152
ULC	CiS	32	0.361	0.042
S	CiS	32	0.559	0.001
FMP	CiU	37	0.041	0.808
FMI	CiU	37	0.164	0.333
MD	CiU	37	-0.039	0.816
BC	CiU	37	0.043	0.801
B	CiU	37	-0.159	0.347
RSA	CiU	37	0.095	0.576
ULC	CiU	37	0.074	0.661
S	CiU	37	0.069	0.687

Note: CiS – subjects with acquired hearing impairment, CiU – subjects with congenital hearing impairment, N – number of subjects in a group, R – Spearman's correlation coefficient, FMP – fine motor precision, FMI – fine motor integration, MD – manual dexterity, BC – bilateral coordination, B – balance, RSA – running speed and agility, ULC – upper-limb coordination, S – strength.

DISCUSSION

When examining the effect of age at onset of hearing impairment on motor skills, no significant relationship was found even between the age at CI placement on the level of motor skills in subjects with cochlear implants. However, when this effect was examined separately in subjects with cochlear implants of different aetiologies of hearing impairment, it was found that there was a significant relationship between age at implant placement and success in four factors – manual manipulation (MD), balance (B), upper-limb coordination (ULC), and strength (S) – in subjects with acquired hearing impairment, whereas no significant correlation was found in subjects with congenital hearing impairment. Subjects with acquired hearing impairment who received cochlear implantation later in life scored better in the observed factors. Cushing et al. (2008) found similar results in their study of balance in children with cochlear implants. They found that age at implantation was not a significant predictor of balance success as measured

by BOT™-2 in children with cochlear implants. However, duration of CI use was a significant predictor of success in balance test – subjects who wore the CI for a shorter period scored better. However, they state that their results should be taken with caution because the sample of subjects was very small and heterogeneous. Furthermore, Gheysen et al. (2008) examined the effects of cochlear implantation on motor skills and noted that age at CI placement did not significantly affect motor skills. Perhaps daily encouragement from parents is the reason that, in this study, the subjects who received the implant later in life performed better. In other words, perhaps the parents of children who received a CI at an earlier age were more protective because of the foreign body implanted in their child's head and did not allow certain games, movements, and activities that stimulate the vestibular apparatus and thus develop balance in early childhood when such activities are crucial for its development. Therefore, subjects who received cochlear implants earlier in life scored lower on the observed factors. The reason why no significant correlation was observed between age at implantation and success in the measured factors in children with congenital hearing impairment may be that their balance deficit (observed under hypothesis 1) is significantly lower at an early age than in children with acquired hearing impairment so that this difference in balance progress is reduced after cochlear implantation.

DISCUSSION

This study aimed to examine the relationship between the motor skill outcomes of students with cochlear implants of different aetiologies of hearing impairment with age at onset of hearing impairment and age at CI placement. The results of the study showed that the age at onset of hearing impairment was not significantly correlated with the level of motor skills. However, the age at cochlear implantation was found to be significantly related to factors of manual dexterity, balance and upper-limb coordination, but only in subjects with acquired hearing impairment in the direction that subjects with acquired hearing impairment who underwent implantation at a later age score significantly better. The results of this study suggest that the age at cochlear implantation has differential effects on motor skills level in subjects with cochlear implants due to different aetiologies of hearing impairment. More precise reasons for the observed effect of age at cochlear implantation on the level of motor skills of children with hearing impairment of different aetiologies with CI could be the subject of new research.

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POVEZANOST MOTORIČKIH SPOSOBNOSTI UČENIKA SA KOHLEARNIM IMPLANTATOM RAZLIČITE ETIOLOGIJE OŠTEĆENJA SLUHA, DOBI U KOJOJ SE OŠTEĆENJE SLUHA POJAVI I DOBI UGRADNJE KOHLEARNOG IMPLANTATA

SAŽETAK

Uvod: Oštećenje sluha jedno je od najčešćih urođenih oštećenja. To ne samo da rezultira djetetovom nesposobnošću da komunicira sa svijetom, već značajno utiče na djetetov emocionalni, socijalni i motorički razvoj. Do danas su istraživanja motoričkog razvoja djece sa kohlearnim implantatima bila ograničena, a ravnoteža kao motorička sposobnost je bila najčešća tema istraživanja. Samo nekoliko studija bavilo se nekim od mnogih aspekata motoričkih sposobnosti kod djece sa kohlearnim implantatima. **Cilj:** Cilj ovog rada bio je ispitati povezanost motoričkih sposobnosti učenika sa kohlearnim implantatom različite etiologije oštećenja sluha, dobi u kojoj se oštećenje sluha pojavi i dobi ugradnje kohlearnog implantata. **Metode:** Istraživanjem je obuhvaćeno ukupno 70 učenika i učenica, u dobi od 6 do 18 godina, upisanih u redovnu osnovnu ili srednju školu. Za utvrđivanje motoričkih sposobnosti učenika korišten je Bruininks-Oseretsky test motoričkih sposobnosti, drugo izdanje. Koristeći Spearmanovu korelaciju ranga, uporedili smo rezultate Bruininks-Oseretsky testa motoričkih sposobnosti sa dobi djeteta u trenutku pojave oštećenja sluha i dobi djeteta u trenutku postavljanja kohlearnog implantata. **Rezultati:** Rezultati istraživanja su pokazali da dob u kojoj se javlja oštećenje sluha nije značajno povezana sa nivoom motoričkih sposobnosti. Međutim, dob u trenutku ugradnje kohlearnog implantata značajno korelira sa spretnosti ruku, ravnotežom, koordinacijom gornjih ekstremiteta i snagom, ali samo kod ispitanika sa stečenim oštećenjem sluha, tj. ispitanici sa stečenim oštećenjem sluha koji su podvrgnuti implantaciji kasnije u životu imali su značajno bolje rezultate. **Zaključak:** Dob pri ugradnji kohlearnog implantata ima različite učinke na motoričke sposobnosti zbog različite etiologije oštećenja sluha kod učenika sa kohlearnim implantatom.

Ključne riječi: kohlearni implantat, motoričke sposobnosti, etiologija oštećenja sluha

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DEVELOPMENT OF A MODIFIED LOUGHBOROUGH SOCCER PASSING TEST

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ABSTRACT

The purpose of this study was to develop the modified Loughborough Soccer Passing Test (MLSPT), assess its validity and reliability, and investigate its relationship to other skill-related fitness metrics, such as speed, agility, accuracy, and reaction time. 90 male students from Burapha University participated in the study. They were divided into three groups according to their short-passing skills: well-skilled (G1), moderately-skilled (G2), and unskilled (G3), each group consisting of 30 people. The rxy method and twice-repeated testing were used in the study to assess the MLSPT's test-retest reliability. The one-way ANOVA statistical test was also used in this study to evaluate the discriminant validity or the capacity to distinguish across groups with distinct information. To investigate the relationship between the MLSPT and physical fitness in relation to football short-range passing and receiving skills, the study used Pearson's correlation coefficient. The study's findings showed that, at the 0.001 level, the MLSPT was able to significantly discern between the three groups of athletes. The MLSPT had a high test-retest reliability of 0.961 and matching values for accuracy, agility, speed, and reaction time of 71.1%, 41.3%, 30.8%, and 18.8%, respectively, at a significant level of 0.001. According to the study's findings, the MLSPT can be used to categorise athletes according to their proficiency with short passes. In addition, the research discovered a correlation of 66.66% between the accuracy, agility, speed, and reaction times of the three groups of athletes. These findings have significant implications for coaches and athletes in identifying and improving specific skill-related fitness measures in soccer players.

Keywords: Loughborough Soccer Passing Test, assessment tool, skill-related fitness, football

INTRODUCTION

Soccer, a widely popular sport also known as football in many countries, demands highly skilled competitors. Excellent coordination, speed, agility, and stamina are required of the players. They need to be adept at ball control, dribbling, passing, and shooting accurately. As a result of the game's unpredictable elements, players must utilise their physiological abilities in combination with perceptual and cognitive functions (Romeas et al., 2016; Hans-Erik & Daniel, 2019). It requires a wide variety of skills from the players. Football players' maximum performance is influenced by four main factors: physical, psychological, technical, and tactical aspects. The ability to accurately pass the ball short distances is an important technical skill that significantly affects performance. In an unpredictable context, it demands the integration of cognitive, perceptual, and motor skills (Russell et al., 2011). All players must become proficient in fundamental skills, such as passing, dribbling, heading, and shooting, to score goals and contribute to their team's success. The ability to throw the ball or ball passing to a teammate at the ideal moment is one of the most important abilities. A team can maintain possession of the ball, create scoring opportunities and

win games by having good passing. A mix of technique, judgment and vision is needed for passing (Bekris et al., 2014). In previous attempts to quantify soccer skills, it was sought out to evaluate technical capabilities, such as passing accuracy, ball control and shooting precision. Even while they are crucial abilities, they do not cover the entire spectrum of abilities needed to succeed in soccer. The Loughborough Soccer Passing Test (LSPT) was created to solve the shortcomings of earlier skill assessment tools. The LSPT is founded on the idea that passing accuracy alone is not sufficient to assess a player's skill level. The player's ability to make decisions is also tested because they must choose the best pass based on the movements of their teammates and opponents (Ali et al., 2007). It has been demonstrated that the test can discriminate between players at various competitive levels and can evaluate the multifaceted soccer skill, including passing, dribbling, control, and decision-making. The LSPT has been demonstrated to be a valid and reliable indication of soccer skill performance through considerable study, and it is used to evaluate passing, dribbling, controlling, and decision-making skills. The players are required to perform a variety of short and long passes under time pressure, as well as demonstrate good ball control and make appropriate judgments based on the movements of their teammates and opponents (Ali, 2011; Ali, et al., 2007; Ali, et al., 2008).

Successful 16 short passes are made to four coloured targets, and scores are kept for movement time, penalty time and overall performance time. Since the objectives are colour-coded, visual memory may have an impact on the location of the targets. Additionally, there is a very small gap between the player and the target, and the ball reflects from the target in unexpected ways (Kellis & Katis, 2007). The main objective of the study was to develop a modified version of the Loughborough Soccer Passing Test (MLSPT), assess its validity and reliability, and investigate the relationship between soccer passing ability and skill-related fitness.

MATERIALS AND METHODS

Participants

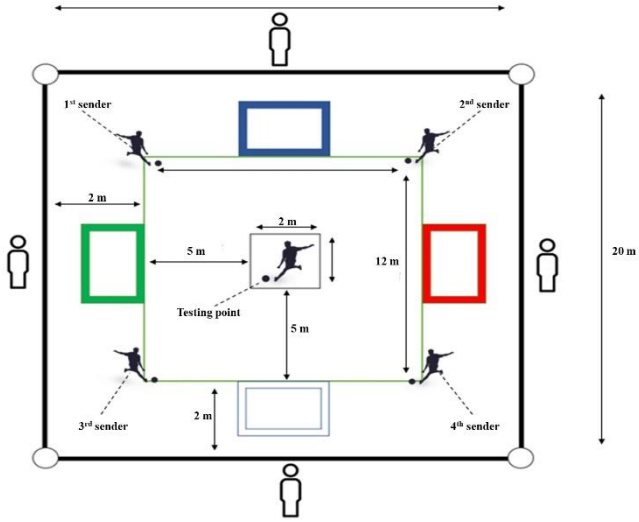
Ninety healthy male university students from Burapha University were selected to participate in this study. They were divided into three groups, each of which had 30 students. The selection process of the sample groups was done using the known group techniques. Based on their short-passing abilities, the students were then sorted into three groups: (1) one with good short-passing skills (G1), (2) one with fair short-passing skills (G2), and (3) one with no short-passing skills (G3). This sample group division allowed for a more comprehensive analysis of the skill-related fitness for passing in soccer in a more thorough manner, and the results could be compared between the groups to produce a more precise assessment. The study has received approval from the Burapha University's Institutional Review Board of Research Ethics Committee, with the assigned identification number of G-HS 119/2563.

Instruments

The MLSPT, a modified version of the Loughborough Soccer Passing Test, has been developed and includes more complex short-passing strategies in soccer. Although the test still adheres to the original framework established by Ali (2007), several computations have been revised to fit the new approach. Three specialists in soccer coaching, sports science and football proficiency have confirmed the test's validity and reliability. In preparation for the testing area, there were instructions that must be followed to get ready. The testing area was first made by positioning four markers to form a rectangle with a 12 m × 12 m size. Then, using 2m × 2m rectangular steel pegs specified as the tester's standing point in the centre of the rectangle with a 12 m × 12 m size, a hemp rope that was dyed to contrast with the testing area had to be pulled taut. The distance from the standing point to the area where the soccer ball was passed was measured to be 5 metres. Four targets were then set up on all four sides of the testing area, each of which was marked with a different colour (blue, green, red, and white). A research assistant was placed between 1-2 metres behind each goal to receive the soccer ball. Furthermore, a research assistant was also placed at each of the four passing sites specified at the corners of the testing area where the ball will be passed. Figure 1 shows the testing area and the positions for research assistants in a graphic manner.

Successful 16 short passes are made to four coloured targets, and scores are kept for movement time, penalty time and overall performance time. Since the objectives are colour-coded, visual memory may have an impact on the location of the targets. Additionally, there is a very small gap between the player and the target, and the ball reflects from the target in unexpected ways (Kellis & Katis, 2007). The main objective of the study was to develop a modified version of the Loughborough Soccer Passing Test (MLSPT), assess its validity and reliability, and investigate the relationship between soccer passing ability and skill-related fitness.

Fig. 1 The modified version of the Loughborough Soccer Passing Test area



Data collection

The participants' individual characteristics were recorded, including their height, weight and medical history. Before engaging in physical activity, they were asked to complete the Physical Activity Readiness Questionnaire (PAR-Q). To evaluate leg proficiency, the kick ball test was used (van Melick et al., 2017). Two markers were placed 2 metres apart to create a target for the kick ball test. A measuring tape was used to determine the target's midpoint distance of 4 metres. Two additional markers were placed to serve as testing points. The participants were signalled by a whistle to kick the soccer ball with their preferred foot into the target. The MLSPT was conducted by the researcher through the following steps:

1. The participants stood at the testing location with their backs to the white target to prepare themselves and wait for the signal.
2. Four research assistants stood in the first, second, third, and fourth positions, respectively, as shown in Figure 1.
3. The research assistants sent the ball to the participants after receiving the start signal. The timer started.
4. The participants received the ball and sent the ball towards the target according to the colour indicated by the research assistants.
5. The test was administered continuously for all 16 rounds per set.
6. In the 16th round, the soccer ball passed through the target, ending the timer.
7. The best time from each set of the test was recorded after it was completed twice with a 5-minute break interval.

Statistical analysis

To describe the fundamental characteristics of the sample, measures including the mean and standard deviation of the sample's age, body weight, height, and other data were computed. The rxy method was used, and repeated testing was done twice, to investigate the test-retest reliability of the applied test. Additionally, using the one-way ANOVA statistical test, discriminant validity and the capacity to distinguish between groups with well-defined knowledge (known-groups validity) were evaluated. Finally, the Pearson's correlation coefficient was calculated to investigate the correlation between the applied test and physical fitness related to short-range football passing and receiving skills. The statistical significance was P 0.05.

RESULTS

The participants were divided into three equal groups as a group with good short-passing skills (G1), a group with fair short-passing skills (G2), and a group with no short-passing skills (G3) according to their passing skill scores obtained from the test. There was no statistically significant difference between these groups (Table 1).

Table 1. General characteristics of the participants

	N	Age (yrs)		Weight (Kgs)		Height (cm)	
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Good short-passing skills (G1)	30	19.77	1.55	71.23	7.27	172.67	2.93
Fair short-passing skills (G2)	30	20.70	0.66	71.97	9.02	171.23	3.83
No short-passing skills (G3)	30	20.53	0.69	72.07	9.25	172.00	3.39

From Table 1, it was found that the mean age of all participants was 20.33 ± 1.11 years, with an average weight of 71.76 ± 8.47 kilogrammes and an average height of 171.97 ± 3.42 centimetres. Preliminary data on leg preference was also available for the sample group, with 84 participants preferring their right leg and 6 participants having a preference for their left leg.

Table 2. Test results for the validity of the MLSPT

				ANOVA			Pairwise comparison		
	$\bar{x}$	SD	SE	F-test	p-value		G1	G2	G3
G1	49.733	4.705	0.859			G1	N/A		
G2	67.967	8.880	1.621	86.549	0.000	G2	18.233**	N/A	
G3	98.167	22.831	4.168			G3	48.433**	30.200**	N/A
Total	**71.956**	**24.620**	**2.595**	Eta (η)	= 0.816				

** Statistical significance was at 0.001

From Table 2, it was found that the MLSPT could distinguish the sample groups. The group with good short-range football passing and receiving skills had an average value of 49.733 ± 4.705 s, the second group with slightly lower short-range football passing and receiving skills had an average value of 67.967 ± 8.880 s, and the group without short-range football passing and receiving skills had an average value of 98.167 ± 22.831 s. Additionally, pairwise comparisons in Table 2 showed significant differences between all groups, with a statistically significant level of 0.001 and an Eta value of 0.816, which represents 66.66% of the relationship between the groups' members.

Based on Figure 2, the MLSPT demonstrated a good level of test-retest dependability with a reliability coefficient of 0.961. There was a statistically significant and strong positive correlation between the test and retest scores, with a significance level of $p < 0.001$. The test-retest was completed on average in 75.567 and 73.944 seconds, respectively. These findings indicate that the MLSPT is a valid and reliable indicator of short-range passing and receiving skills in football.

Fig. 2 The analysis of correlation and test-retest reliability of the MLSPT

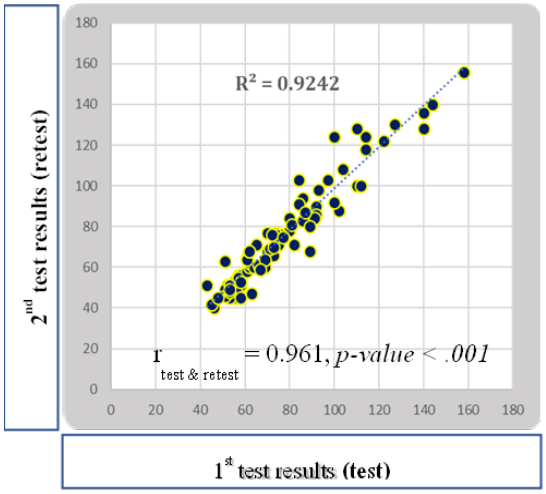


Table 3. Test results for the correlation between the short-range football passing and receiving skills test of the MLSPT and a physical fitness related to short-range football passing and receiving skills

	Speed	Agility	Accuracy	Response	MLSPT	R^2(%)
Speed	1.000	0.587	0.230	0.146	0.308	**30.8%**
Agility	0.766	1.000	0.336	0.270	0.413	**41.3%**
Accuracy	-0.480	-0.580	1.000	0.286	0.711	**71.1%**
Response	0.382	0.520	-0.535	1.000	0.188	**18.8%**
MLSPT	0.555	0.643	-0.843	0.434	1.000	

* R2 means percentage of correlation

According to Table 3, it was revealed that the MLSPT was compatible with physical fitness related to the skills of short-range football receiving and passing accuracy, flexibility, agility, speed, and reaction time, with coefficients of determination of 71.1%, 41.3%, 30.8%, and 18.8%, respectively. Additionally, whereas the skill related to flexibility, agility and speed had a coefficient of regression of 0.231 and t = 3.495**, the skill related to accuracy had a coefficient of regression of -0.709 and t = -10.713**.

DISCUSSION

According to research on the validity and reliability of the short-range football passing and receiving test, the research found that the MLSPT had moderate to high levels of confidence. This is consistent with the literature study by Clemente et al. (2022) who stated that the confidence in the test is a primary factor in assessing its validity. Furthermore, as shown by the research findings in Table 2, the MLSPT was proven to be reliable in distinguishing between groups. Our research utilised a clear-cut sampling method like that of Le Moal et al. (2014) in their study of the validity and reliability of the short-range football passing and receiving test using the LSPT in a sample group of 87 athletes. The sample group was comprised of elite athletes, secondary-level athletes and non-athletes. With statistically significant differences at the .001 level, the study discovered that the LSPT could successfully identify between the sample groups. It should be mentioned that the LSPT is being employed to evaluate short-range passing and receiving abilities in football. The existence of a testing method that corresponds to the tactics of receiving and passing in football, involving the act of kicking the football to make it bounce off a post and redirecting it towards the next goal and simulating game situations where football players must continuously receive and pass the ball while attempting to attack and score is a means of improving their skills and performance (Yenjit, 2010). Previous studies had also shown that environmental awareness was a significant aspect that influenced the skills of receiving and passing a football. According to a study by McGuckian et al. (2019), it was suggested that football players must continually shift or swivel their heads to be aware of their surroundings to obtain information that would enable them to make decisions about moving the ball more quickly. The capacity to select and make decisions to achieve the best possible outcome from the set of data is known as decision-making competence (Bar-Eli et al., 2011).

Therefore, to receive and identify the intended target for passing, the MLSPT of the present study makes use of aural perception. Using the procedure illustrated in Figure 1, the researchers delivered audio signals from four distinct football delivery spots that were randomly chosen. As a result, participants had to engage in a more complex cognitive process to decode the auditory information, assessing the direction of the sound to receive the football and processing the command to identify the coloured target for passing. This differs from previous approaches which only required processing the coloured target from the auditory input. Additionally, since a human's visual field is between 180 and 200 degrees, participants were already aware of the direction in which the football would rebound and used visual perception to select the correct target (Hopf et al., 2000). When receiving a football, the original LSPT had a perspective that made three of the four targets visible, allowing for target direction prediction from the periphery of the visual field. However, in the MLSPT, only two of the four targets can be seen as the player turns to receive the ball from the sending point. This made it difficult for participants to predict and remember the target that the ball should be passed to as a result. Therefore, during the 16 rounds of the test, participants had to continuously be aware of their surrounding environment. The researchers employed small-sized football goals as targets, which allow the ball to travel through without bouncing back like the original wooden board targets, to imitate the situation in which football players must constantly perceive the surrounding environment throughout a game. The aim of the study is still the same despite the variations and necessary modifications to the testing procedures, as described above. The study's findings showed that the MLSPT is statistically accurate and confident in differentiating across groups based on their level of proficiency in short passing and receiving skills. The test was able to differentiate between three groups of individuals who possessed good short passing and receiving skills: those with good short passing and receiving skills, those with slightly less proficient short passing and receiving skills and those lacking in both abilities. Based on how each participant performed on the test, the researchers were able to clearly divide the participants into three categories. These findings were consistent with those of Wen (2018), and the test could be used to evaluate football players' short passing and receiving abilities in real-world situations. The researchers chose four physical fitness skills for the purposes of the study because there was a correlation between the results of the MLSPT and physical fitness tests related to short-passing and receiving skills. These four physical fitness abilities were reaction time, accuracy, agility, and speed. According to the research findings, the MLSPT was associated with physical fitness in terms of accuracy, agility, speed, and reaction time, respectively, in relation to short-passing and receiving skills, as shown in Table 3. Additionally, according to the research results, the MLSPT performance was significantly correlated with both accuracy and agility. The specific skill-related physical fitness of football had a relatively high specificity which was congruent with the MLSPT, with a high percentage of up to 71.1%. If any of the measured physical fitness variables, including accuracy, agility, speed, and reaction time, are high, the net time of the MLSPT could be performed well.

Football players with a lot of experience and consistent training in the sport exhibit highly proficient talents as well as expertise developed through repetition of unique football-specific skills. A person was more likely to perform well in the applied short-range ball passing and receiving test of the Loughborough Soccer Passing and Receiving Test if they had strong accuracy in short-range ball passing and receiving skills (Ericsson et al., 1993). Additionally, Edis (2021) also discovered a relationship between strong performance in change of direction and good football skills, as the nature of football relies on constant movement and change of direction. Athletes required bodily agility, flexible joints and quickness to achieve the correct position for receiving and passing the ball with appropriate timing. Soccer players were also required to move rapidly to approach the ball after making effective direction changes. According to the research, speed was correlated with soccer at a rate of 30.8%, which indicated a relationship between speed skills and the sport. Running was an essential ability needed for soccer, since speed was the capacity to travel from one place to another in the least amount of time (Pescatello, 2014). Additionally, speed is necessary to approach the ball to receive and pass it. Soccer players would have a higher chance of receiving and passing the ball swiftly if they can get to it quickly. Soccer players with experience understood and comprehended the context of it. This enabled them to select the ideal body movements for receiving and delivering the ball swiftly, precisely and effectively (Overney et al., 2008). The ability to receive and pass a football is most influenced by all the fundamental physical abilities and specific skills (BenOunis, 2013). However, studies had indicated that one of the critical fundamentals of playing football was having a good general awareness of the environment (Department of Physical Education, 2012). Football players must turn their heads continually to use their visual senses to perceive their surroundings, their mouths to communicate with their teammates and their ears to perceive signals from the surrounding noise. The body's perception and reaction are involved in each of these processes. Before entering the central brain's analytical process and triggering a response in the form of motion, the entire process began with the perception of signals from hearing and seeing. The ability to respond to stimuli during testing was defined by reaction time and the speed of movement when performing bodily actions, according to research on reaction time and movement time ability (Magill, 2003). These skills were demonstrated in the

ability to receive and pass a football. Even though the research findings indicated that the time of the reaction was only 18.8% compatible with the short-range pass and receiving test of the employed LPST model, however, it could indicate the test results to some extent. This was due to the fact that a tester with a quick reaction time would be able to perceive the surroundings more quickly. It was also possible for commands to be responded to more quickly, even in a split second. This was because, after receiving the ball, football players frequently had to decide whether to shoot, dribble or pass the ball in actual game situations. One of the processes in the decision-making was making a decision in a split second with the best option for the circumstance (Romeas et al., 2016). For athletes, observing the environment is similar to gathering information, which is a step in the decision-making process. Making a decision would take less time when there was enough information, which would allow for a quicker reaction to an emergency situation. The reaction time varied with accuracy in receiving and passing the ball, according to Hicheur's study (2017). This was a measure that could be divided into various groups of samples. A technique known as "speed discrimination" was used by experienced football players to make decisions based on their body movements and employ skills that are appropriate for quick-response situations (Huang et al., 2008). According to this research's findings, the group with strong short-range passing and receiving skills in football had an average reaction time of 0.995 seconds, while the group with less skills had an average reaction time of 1.031 seconds. The group lacking short-range passing and receiving abilities in football had an average response time of 1.150 seconds. This suggested that the group with the best short-range passing and receiving football skills was able to recognise and react to specific situations more quickly and accurately than the other groups. This was consistent with the previous assertion.

CONCLUSIONS

The MLSPT had been demonstrated to have high reliability and validity, making it a valuable tool for classifying athletes according to their performance. The test had shown a significant correlation of 66.66% between groups in crucial domains, such as precision, agility, speed, and reaction time. This showed that the MLSPT can be a useful tool for coaches, trainers and sports scientists looking to assess and compare athletic skills across multiple levels and circumstances.

CONFLICTS OF INTEREST

The authors do not have any conflicts of interest to declare.

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RAZVOJ MODIFIKOVANOG LOUGHBOROUGH TESTA DODAVANJA LOPTE U FUDBALU

SAŽETAK

Svrha ove studije je razviti modifikovani Loughborough test dodavanja lopte u fudbalu (MLSPT), procijeniti njegovu valjanost i pouzdanost te istražiti povezanost sa drugim parametrima kondicije poput brzine, agilnosti, preciznosti i vremena reakcije. 90 studenata sa Burapha Univerziteta je učestvovalo u studiji. Podijeljeni su u tri grupe na osnovu njihovih vještina kratkih dodavanja: veoma vješti (G1), umjereno vješti (G2) i nevješti (G3), a svaka grupa se sastojala od 30 osoba. U studiji je korištena metoda rxy i dvostruko testiranje kako bi se izvršila procjena test-retest pouzdanosti MLSPT-a. Statistički test jednostruke ANOVA-e je također korišten u ovoj studiji kako bi se procijenila diskriminativna valjanost ili mogućnost razlikovanja među grupama sa različitim informacijama. Pearsonov koeficijent korelacije je korišten za istraživanje povezanosti između MLSPT-a i kondicije u odnosu na vještine kratkih dodavanja i primanja lopte. Pronalasci studije su pokazali da je MLSPT mogao značajno razlikovati tri grupe sportista na nivou 0,001. MLSPT je imao visoku test-retest pouzdanost od 0,961 te odgovarajuće vrijednosti za preciznost, agilnost, brzinu i vrijeme reakcije od 71.1%, 41.3%, 30.8% i 18.8%, a na značajnom nivou 0.001. MLSPT se, u skladu sa pronalascima studije, može koristiti za klasifikovanje sportista prema njihovim sposobnostima po pitanju kratkih dodavanja. Nadalje, istraživanje je otkrilo korelaciju od 66,66% između preciznosti, agilnosti, brzine i vremena reakcije kod tri grupe sportista. Ovi pronalasci imaju značajne implikacije za trenere i sportiste u identifikaciji i poboljšavanju specifičnih kondicionih mjera povezanih sa vještinama kod fudbalera.

Ključne riječi: Loughborough test dodavanja lopte u fudbalu, alat za procjenu, kondicija povezana sa vještinama, fudbal

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DIFFERENCES IN SITUATIONAL-MOTOR ABILITIES BETWEEN BOYS AND GIRLS IN THE FIFTH GRADE OF ELEMENTARY SCHOOL

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ABSTRACT

Background: Physical activity is a basic human need from birth to old age. Regular physical activity is one of the ways we can influence children's health. That is why it is important to develop habits of regular physical exercise in children, which will continue throughout life and become a part of everyday life. Children's physical activity has a positive impact on their development and health. **Aim:** The aim of this research is to determine the differences in situational-motor abilities between boys and girls in the fifth grade of elementary school. **Methods:** The research was conducted on a sample of N = 110 students, divided into two subsamples: a subsample of 55 students (boys) in the fifth grade of nine-year education named GR-A, and a subsample of 55 students (girls) in the fifth grade of nine-year education named GR-B. For the assessment of the situational-motor skills, twelve variables were used. Descriptive statistics were used for data processing, and the t-test was used to determine the differences. **Results:** The research results showed that visible differences in situational-motor tests in favour of boys are statistically significant. The biggest difference in favour of boys is in the disciplines of juggling the ball (SMFZ), leading the ball in slalom (SMFVLS), impact power (SMFSU), and throwing the ball in the basket (SMKBLK). **Conclusion:** In the earlier period of childhood, male students are more physically active than most female students, and their "starter" is a tendency towards winning values (desire to win), while social motives directed towards skill improvement prevail among girls. It is necessary to involve students as much as possible in additional physical activities, especially when in this population. Despite the planned three lessons per week, only one lesson of Physical and Health Education per week is performed in the sports hall and often in inappropriate conditions. By creating a constant habit of playing sports, the desired transformations of children will occur over time.

Keywords: differences, gender, situational-motor ability, physical education, students

INTRODUCTION

In the educational system, there are mostly four sports games in Physical and Health Education classes: handball, basketball, football, and volleyball. Each of these games has its own characteristics, both in terms of the movement structure itself and in terms of the impact on the body. The goal of using sports games is not to create results for students, but can be viewed in two directions: the importance of games from the educational and the upbringing aspect. From an educational point of view, sports games are extremely important for: preserving health, especially in correcting bad posture, adopting new complex movements and strengthening movement structures that children can apply in everyday life. In the upbringing sense, sports games contribute to: socialisation of players - because it is impossible to achieve a result without the cooperation of players, individualisation of students - when in certain moments they need to take on the role of themselves to get the winner, ethics - because we have to respect the rules in order to reach the goal, the development of a positive attitude towards work - in order to adopt a movement structure, a large number of repetitions are necessary, and more quality spending of free time. In order to use the teaching content of physical education to affect the students' anthropological status, their proper growth and the development of their abilities, it is necessary to determine the current state of the students' anthropological status, determine the guidelines for their transformation and provide feedback on the achieved level of transformations (Stanković, 2002). Physical and health education is an integral part of the educational process and has the task of positive transformation of personality dimensions throughout all ages (Prskalo & Findak, 2003). Any additional sports activity leads to a certain transformation of the motor and even morphological status. The most important thing is to adapt a certain sports activity to the age in question so that the activity affects the transformation of students (Rašidagić et al., 2000). Determining the differences between girls and boys in motor skills is still insufficiently researched, but a very current theoretical and practical problem is of particular importance due to planning, programming, and monitoring and evaluation in the teaching of Physical and Health Education, as well as for orientation and selection of young athletes, planning, programming and control of the training process, and effective monitoring of the development of relevant anthropological characteristics among athletes and students (Findak, 2003). Some motor abilities are more and some less innate, that is, genetically conditioned. Certain motor abilities can be influenced to a greater or lesser extent than others, which depends on the coefficient of innateness (h2) of the individual ability, gender and age. Strength development can be effectively influenced throughout life, while abilities such as speed, coordination and agility can only be influenced in early childhood. Strength is a motor ability that is 50% genetically determined, and 50% of this significant motor ability is subject to development throughout life. Unlike strength, speed is 80-95% innate, so the influence on the development of speed is much less possible when compared to strength and ranges from 5-20% (Pistotnik, 2003). On a sample of 146 male students, Hadžikadunić (2007) determined transformational processes under the influence of programmed Physical and Health Education classes lasting 69 hours on basic motor, situational-motor and functional abilities of eighth-grade students. A variable system of 8 tests for basic motor abilities, 9 tests for the assessment of specific motor abilities and one test for the assessment of functional abilities was used. It was determined that programmed teaching has a positive impact on the improvement of basic motor, situational-motor and functional abilities. On a sample of 146 male students, Hadžikadunić (2007) determined transformational processes under the influence of programmed Physical and Health Education classes lasting 69 hours on the situational-motor abilities of eighth-grade students. A variable system of 9 tests was used to assess situational-motor abilities. It was determined that programmed teaching has a positive influence on the improvement of situational-motor abilities. Lakota et al. (2008) determined the qualitative level of transformations of situational motor abilities in handball players aged 11-14 years for a period of three months. The sample consisted of 82 male respondents. Factor analysis isolated 73% of the common variability. The results indicate that qualitative changes were shown in hitting the target with the ball, as well as the speed of movements related to ball control. In his work "Structural changes in sports games in physical education lessons", Mladenović (2008) implemented the contents of sports games in physical education lessons for a school year with a sample of 152 students. By applying the treatment, an attempt was made to determine the level of structural changes in basic and specific motor skills. The results of this programme showed a general, systematic, continuous reconstruction of general and specific motor abilities, and therefore the transformation process is responsible, although not in all situations to the same extent. The weakest effects were recorded in the case of football. Handball is a game of extremely fast, explosive and multiple complex movements, development of actions, situational problem solving, which all together characterises the level of activity intensity, which requires a high level of ability from the player, both basic and specific. The existence of five latent situational-motor dimensions in handball has been confirmed by numerous

authors, namely: accuracy, ball handling, players' speed of movement when handling the ball, players' speed of movement without the ball, and the power of throwing the ball (Pavlović et al., 2013). Children with the best coordination are also the most active, and children with motor problems participate less in regular physical activities (Aaltonen et al., 2015). Owing to the positive health effects of physical exercise, Physical Education is an integral part of the educational system, with two lessons a week, which is insufficient to achieve the optimal effect in transforming the anthropological status of children (Nikšić et al., 2019). The contents that are processed the most and that are the most popular in all educational systems in classroom teaching are contents from sports games. The number of hours during which certain sports are covered is not enough, so in five years of primary education, we have an average of about 32 hours for one sports game, and therefore we cannot even talk about the adoption of movement structures which will be able to be applied in life. It is also a fact that the development of our school system, especially Physical and Health Education, is very low. The lack of material means and space for exercise is a limiting factor for the performance of all the contents foreseen in the curriculum (Nikšić, Beganović, & Joksimović, 2020).

MATERIALS AND METHODS

Participants

The sample of respondents, designated as GR-AB, includes 110 students, divided into two sub-samples: a sub-sample of 55 students (boys) of the fifth grade of nine-year education designated as GR-A, and a sub-sample of 55 students (girls) of the fifth grade of nine-year education designated as GR-B. The initial classification was made solely on the basis of participation or non-involvement of students in sports training as an additional physical activity.

The sample of variables

For the assessment of situational-motor skills, twelve variables were used. Basketball - 3 variables: Throwing the ball with both hands against the wall and catching it for 30 seconds (SMKBLRZ); Leading the ball in slalom (SMKVLS); and Throwing the ball into the basket for 30 seconds (SMKBLK). Volleyball - 3 variables: Lower front serve (SMOSD); Shooting a target over a grid from a basic stance (SMOGCPM); and Forearm bounce in a circle for 30 seconds (SMOOLPK). Handball - 3 variables: Throwing and catching the ball against the wall for 30 seconds (SMRBLZ); Leading the ball in slalom (SMRVLS); and Performing the sevens (SMRIS). Soccer - 3 variables: Juggling the ball (SMFZ); Leading the ball in slalom (SMFVLS); and Impact Power (SMFSU).

Statistical analysis

From statistical methods, the following tests were applied: descriptive statistics, Kolmogorov-Smirnov test and t-test. Using the t-test, the differences of the variables for assessing the situational motor performance between boys and girls in the fifth grade of early childhood education were determined. Statistical processing of the data in this research was done using the computer software SPSS statistics 20.0 in the operating system Windows 10. The statistical program for personal computers SPSS for Windows version 22 was used for data processing. The level of inference was set at $p < 0.05$.

Results

Table 1: T-test of pairs of identical subsample variables

		Paired Samples Test							
		Paired Differences							
	Groups				95% Confidence Interval of the Difference		t		Sig.
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper		df	(2-tailed)
Pair 1	MRUK01 - ZRUK01	.70909	6.61276	.89166	-1.07859	2.49677	.795	54	.430
Pair 2	MRUK02 - ZRUK02	1.76418	3.81092	.51386	.73395	2.79442	3.433	54	**.001**
Pair 3	MRUK03 - ZRUK03	.94545	3.37978	.45573	.03177	1.85914	2.075	54	**.043**
Pair 4	MFUD01 - ZFUD01	9.21818	10.01238	1.35007	6.51146	11.92491	6.828	54	**.000**

Pair 5	MFUD02 - ZFUD02	4.95455	4.96109	.66895	3.61337	6.29572	7.406	54	**.000**
Pair 6	MFUD03 - ZFUD03	9.12727	6.92568	.93386	7.25500	10.99955	9.774	54	**.000**
Pair 7	MKOS01 - ZKOS01	1.50909	7.02343	.94704	-.38961	3.40779	1.593	54	.117
Pair 8	MKOS02 - ZKOS02	1.96109	3.40902	.45967	1.03950	2.88268	4.266	54	**.000**
Pair 9	MKOS03 - ZKOS03	-.50909	2.72079	.36687	-1.24462	.22644	-1.388	54	.171
Pair 10	MODB01 - ZODB01	-.20000	3.34664	.45126	-1.10472	.70472	-.443	54	.659
Pair 11	MODB02 - ZODB02	-1.03636	3.28838	.44341	-1.92534	-.14739	-2.337	54	**.023**
Pair 12	MODB03 - ZODB03	3.69091	12.59023	1.69767	.28729	7.09452	2.174	54	**.034**

The analysis of the presented t-test (Table 1) results showed that visible differences in situational motor tests in favour of boys are statistically significant. If we ignore pubertal changes for the most part, there are statistically significant differences in the results achieved between male and female students, and all students practice under the same conditions and under the guidance of the same teachers. In general, it could be said that the students who practice some kind of sports activity showed better results on all tests.

Table 2. T-test of pairs of identical sample variables

Groups		Paired Samples Test							
		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	MRUK – ZRUK	.04023	.47548	.06793	-.09634	.17680	.592	48	.556
Pair 2	MFUD – ZFUD	.00366	.40522	.05674	-.11031	.11763	.064	50	.949
Pair 3	MKOS – ZKOS	-.01903	.40090	.05614	-.13179	.09372	-.339	50	.736
Pair 4	MODB - ZODB	.02673	.40734	.05704	-.08784	.14130	.469	50	.641

It can be assumed that, in the earlier period of childhood, male students were more physically active than the majority of female students, and their "starter" is a tendency towards winning values (desire to win), while social motives aimed at improving skills prevail among girls. As in the basis of each shown sports discipline with motor learning, it is assumed that the boys had better foundations for upgrading their knowledge and skills in terms of a better motor-functional base. The biggest difference in favour of boys is in the disciplines of juggling the ball (SMFZ), leading the ball in slalom (SMFVLS), impact power (SMFSU), and throwing the ball into the basket (SMKBLK) (Table 2). These natural forms of movement are very complex and require students to be extremely skilled in space. In their performance, coordination, explosive power, speed, and precision are united, that is, four basic motor abilities that should be developed at the earliest age of childhood, and they are highly correlated with the other analysed sports disciplines. Children in preschool age move intensively, most often in play, and it is a misconception that they have a hard time enduring physical exertion. And if their physical activity changes when they start school, they unconsciously form their motoric - functional "image" much earlier. The desire to compete and prove oneself,

where students set their own performance standards, is also an important factor in the practice process. The social component is a very important factor, where the feeling of "belonging" to a certain group can in many ways motivate students to a certain activity. It is important that even "weaker" students feel that they can be successful in this area, which stimulates their commitment and motivation, while the role of the teacher is very important; he must motivate, create and maximally encourage the individual progress of students. As can be seen from Table 2, all dependent variables meet the criteria of normality (not significantly curved, flattened or elongated) both at the level of subsamples formed by gender and at the level of the entire sample.

DISCUSSION

Teaching implemented in Physical and Health Education classes should be exclusively planned and highly organised because only such teaching can ensure the realisation of the intended goals and tasks. The programme content that is implemented in classes and derives from the current curriculum for teaching Physical and Health Education implies a careful methodical approach of the teacher in the operationalisation of the set goals and tasks and the choice of methods and organisational forms of work, all with the aim of more effective adoption of the content. The methodical approach and application of methods in the appropriate forms of work in teaching differ from teacher to teacher, which represents a certain individuality of the teacher in the approach and application of methods in order to adopt the intended teaching contents. This should not be a problem, given the fact that teaching methods arise from teaching practice, and accordingly, the attitude towards them should be "necessarily creative". In the field of teaching methods, the teacher constantly combines existing methods, invents new ways and methods of training, and thus introduces innovations and, characteristically for every teacher, his own work methods. Due to the presence of "personal" in the application of methods, some authors point out that methods cannot be talked about in the sense of the existence of general methods, but only of their own methods. The growth and development of the child in this period is, above all, characterised by slow physical growth, the beginning of intensive muscle growth, a high level of development of movement coordination, a certain level of intellectual development for accepting group instructions, social development for cooperative relationships with peers, and, due to the workload at school, excess body energy that can be successfully released in physical activities. In order to determine the influence of some motor skills on the differences between boys and girls in sports games (basketball, volleyball, football, and handball) planned in Physical and Health Education lessons for fifth-grade elementary school students, the results obtained on the sample were analysed for 110 respondents aged 10 to 12 years. Considering that in the lower grades of elementary school, students perform their tasks equally, this is not the case here. Therefore, according to the obtained results in the motor area, significant differences were observed between boys and girls in the tests of juggling, guiding the ball in slalom, impact force, and forearm bounce. Sports areas are "divided"; it can be said that football and handball are easier for boys, more precisely, boys achieved better results in all tests, and basketball and volleyball are thought to be easier for girls because there are tests in which girls had better results than boys. There are different reasons for such results. Some of them are the lack of interest of female students in these fields, inexperience of teachers, poor working conditions, difficulties in development, insufficient work of students, etc. The most common cause during student testing was lack of interest and refusal to take certain tests. The girls protested but were also afraid to do soccer tests. The reason for such behaviour is because they never play that sport except when they had to. This was clearly seen in the obtained results, where drastic differences were made. While from other areas, we can say that there are no big deviations in both groups of students. This means that the hypothesis is correct for all areas except football, but probably with more active work and exercise, those results would be similar between the groups. Although the highlighted results have special importance in planning and programming transformation processes as indicators of the initial status of students, the significance of the recorded differences between boys and girls cannot be generalised to the entire population of fifth-grade students in Bosnia and Herzegovina. The obtained results may be the result of other factors that were not the subject of this research. For example, children come to the fifth grade with very different motor skills, which can significantly affect the development of their motor skills. Recorded differences in motor status between boys and girls need to be taken into account when forming homogeneous groups in classes, and also in the development of precision, explosive power, speed, and coordination. In this period, the muscular strength of boys is greater than that of girls. Between the ages of 11 and 15, girls reach puberty and overtake boys in growth, but not in strength. This is confirmed by the tests conducted with this group of students, and it is most noticeable in the test of the shot power in the field of football. Boys and girls cannot form one homogeneous group in the performance of sports disciplines, while in order to develop repetitive and static strength as well as coordination in rhythm, they can, but only in the fifth grade of elementary school in the researched population. Such research in the function of improving the quality of Physical and Health

Education teaching confirms the need to analyse the initial conditions at the beginning of the school year, where differences must be respected and the curriculum and plan in Physical and Health Education must be adjusted accordingly. For the second elementary school cycle, which includes the 4th, 5th, and 6th grade of elementary school, the gradual and progressive differentiation of girls and boys in morphological, motor and functional features is characteristic. Therefore, the teaching of Physical and Health Education should be gradually directed towards the optimal development and improvement of the knowledge, abilities and qualities that are essential for students in this and the next developmental period. Due to the biological and accompanying psychosociological differences between male and female students, from the point of view of scientific and professional knowledge, the subject teaching of Physical and Health Education should be organised separately for female students and separately for male students. In sports games, it is important to accurately perform simple and complex skills as quickly as possible in the given time and in the continuously changing environment due to the presence of opponents. The coordination requirements set before athletes in sports games are shown in Table 2. Taking volleyball and football as examples of sports games, guided by Table 2, we can see the accuracy. Namely, with volleyball, you need to have a feel for the ball, as well as accurate rebounding, passing and hitting the ball, which has been shown to be more favourable to girls. While in football, it is the other way around, so it is said that this sport requires good coordination, orientation and balance, which is the case with boys. All of these are motor skills that are more or less innate, but they can all be developed if they are practiced regularly. We cannot precisely and accurately compare the given definitions with the examined samples because after all, several tests were examined, and not the way of playing these sports. Dimitrić and Pantović (2011) as well as Krsmanović and Radosav (2008) came to the conclusion that the level of motor skills' expression in younger school age differs significantly depending on gender. Boys exhibit a higher level of explosive strength and coordination and girls a higher level of flexibility. In his work "Structural changes in sports games in physical education lessons", Mladenović (2008) implemented the contents of sports games in physical education lessons for a school year with a sample of 152 students. By applying the treatment, an attempt was made to determine the level of structural changes in basic and specific motor skills. The results of this programme showed a general, systematic, continuous reconstruction of general and specific motor abilities, and therefore the transformation process is responsible, although not in all situations to the same extent. The weakest effects were recorded in the case of football. The results of research on motor abilities of students in younger grades of elementary school show a trend of decreasing motor abilities in students of both genders (Kraljević, Gadžić, & Vučković, 2013). The development of motor skills should be the key to development in childhood, which will continue later in adolescence (Barnett et al., 2008). Among students of younger school age, there are differences in motor abilities, as well as overall anthropological status between boys and girls, and this difference especially occurs between the ages of 10 and 14 (Katić et al., 2005). The aim of the paper is to determine whether there is a statistically significant difference in motor skills between male and female students of the 5th and 6th grade of elementary school. The results of the discriminant analysis show the existence of a statistically significant difference between boys and girls in the 5th and 6th grades in motor skills ($p = 0.00$), and this significance increases with increasing age. The biggest differences are evident in the areas of coordination and explosive strength in favour of boys ($p = 0.00$) and flexibility in favour of girls ($p = 0.00$). Based on the obtained results, it can be concluded that boys and girls differ in their motor skills already from the age of 11. Boys are more dominant in abilities that develop under the influence of physical exercise, while girls show much better results in flexibility. It can certainly be concluded that irregular physical exercise results in a weaker development of motor skills in girls, compared to boys (Badrić, 2011). The development of motor skills is to some extent determined by the genetic structure inherited from the parents, and to a large extent it develops under the influence of transformational kinesiology processes and the environmental conditions in which the individual lives and develops. Engaging in physical activities within the school and its programme enables every child to satisfy the need for movement, play, belonging, development of competitive spirit, and socialisation. Physical activity should be aligned with the laws of children's development and should be aimed at developing functional and motor skills. It is necessary to know the elements that we can act on and that are essential for the realisation of kinesiology activities if we want to achieve the development of motor potential (Tešanović, Ćirković, Nikolić, & Vučetić, 2018). The goal of the research was to determine the effects of specially programmed Physical and Health Education classes with the application of content from sports games (basketball, volleyball and handball) lasting one semester on qualitative changes in situational-motor skills in fifth-grade elementary school students. The research included N = 106 5th grade students, ages 10 to 11. Nine variables were used to assess situational-motor skills. Descriptive statistics, t-test and factor analysis were used in order to determine qualitative changes in situational-motor abilities. The results of the t-test showed that the results were statistically significant at levels less than 1% for the variable SMKVLS, and at levels less than 5% for the variables SMRBLZ and SMRVLS. The improvement of situational-

motor abilities, as well as the overall anthropological status, depends on the application of content in Physical and Health Education classes, as well as their adaptation to the age of the students with whom they work (Nikšić, Beganović, & Joksimović, 2020).

CONCLUSION

This research was conducted with the aim of determining the differences in situational-motor skills between boys and girls in the fifth grade of elementary school. The research was conducted on a sample of N = 110 students, divided into two subsamples: a subsample of 55 students (boys) in the fifth grade of nine-year education named GR-A, and a subsample of 55 students (girls) in the fifth grade of nine-year education named GR-B. To assess situational motor skills, 12 variables were used. Basketball - 3 variables: Throwing the ball with both hands against the wall and catching it for 30 seconds (SMKBLRZ); Leading the ball in slalom (SMKVLS); and Throwing the ball into the basket for 30 seconds (SMKBLK). Volleyball - 3 variables: Lower front serve (SMOSD); Shooting a target over a grid from a basic stance (SMOGCPM); and Forearm bounce in a circle for 30 seconds (SMOOLPK). Handball - 3 variables: Throwing and catching the ball against the wall for 30 seconds (SMRBLZ); Leading the ball in slalom (SMRVLS); and Performing the sevens (SMRIS). Soccer - 3 variables: Juggling the ball (SMFZ); Leading the ball in slalom (SMFVLS); and Impact Power (SMFSU). Descriptive statistics and the Kolmogorov-Smirnov test were used for data processing, and the t-test was used to determine differences. The research results showed that there are statistically significant differences in situational motor tests in favour of boys. Test codes: Throwing the ball with both hands against the wall (SMKBLZ), Leading the ball in a slalom (SMKVLS), Throwing the ball into the basket (SMKBLK), Hammer hit in the circle, (SMOOCK), Lower front serve (SMOS), Performing the sevens (SMRSED), Throwing the ball against the wall (SMRBLZ), Leading the ball in slalom (SMRVLS). There is a statistically significant difference between boys and girls in favour of boys. In the test Aiming at a target through a net from a basic stance (MODB2), in boys and (ZODB2), in girls, they showed that the results of GR-B moved towards the zone of better results. It is clear that the motor ability of precision plays a big role in the correct performance of the task, which the girls showed and achieved a better result. The biggest difference in favour of boys is in the disciplines of juggling the ball (SMFZ), leading the ball in slalom (SMFVLS), impact power (SMFSU), and throwing the ball in the basket (SMKBLK). In the ball-juggling test, boys needed about 15 seconds for this task and girls about 20 seconds. As for the power of the shot, the boys achieved better results. GR-A achieved its strength in this task at about 20m, while GR-B at about 12m. Based on the variable Throwing the ball with both hands against the wall, it is clear that the boys achieved a better result in this task in the field of basketball and are again ahead of the girls. In the test codes Throwing the ball into the basket; Lower front serve and Shooting the target over the net from the basic stance, GR-B achieved better results. This shows that one of their motor abilities, precision, is better developed. In the earlier period of childhood, male students are more physically active than most female students, and their "starter" is a tendency towards winning values (desire to win), while social motives directed towards skill improvement prevail among girls. Considering the indivisibility of the multistructural and multifunctional nature of the anthropological space, we can say that engaging in sports activities, such as basketball, volleyball, handball, and football, is an important factor in the development of children of younger elementary school age. It is especially the case when in that population, despite the planned three lessons per week, only one lesson of Physical and Health Education per week is realised in the sports hall and often in inappropriate conditions. On the other hand, respecting the share of kinesiology activities in profiling the kinesiology and anthropological status of students is an irreparably important developmental period for them. It is necessary to include as many children as possible in additional physical activities, considering that the teaching of Physical and Health Education is not enough to cause significant changes in the children's organism.

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CONFLICTS OF INTEREST

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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RAZLIKE U SITUACIJSKO-MOTORIČKIM SPOSOBNOSTIMA DJEČAKA I DJEVOJČICA PETOG RAZREDA OSNOVNE ŠKOLE

SAŽETAK

Kontekst: Fizička aktivnost je osnovna ljudska potreba od rođenja do starosti. Redovna fizička aktivnost predstavlja jedan od načina na koji možemo uticati na zdravlje djece. Zbog toga je važno razviti navike redovne fizičke aktivnosti kod djece, a što će se nastaviti tokom života i postati dio svakodnevnice. Fizička aktivnost djece ima pozitivan uticaj na njihov razvoj i zdravlje. **Cilj:** Cilj ovog istraživanja je utvrditi razlike u situacijsko-motoričkim sposobnostima dječaka i djevojčica petog razreda osnovne škole. **Metode:** Istraživanje je provedeno na uzorku od N = 110 učenika koji su podijeljeni u dva poduzorka: poduzorak GR-A koji se sastoji od 55 učenika (dječaka) petog razreda devetogodišnjeg obrazovanja i poduzorak GR-B koji se sastoji od 55 učenika (djevojčica) petog razreda devetogodišnjeg obrazovanja. Za procjenu situacijsko-motoričkih sposobnosti korišteno je dvanaest varijabli. Deskriptivna statistika je korištena za obradu podataka, a t-test je korišten za utvrđivanje razlika. **Rezultati:** Rezultati istraživanja su pokazali da su vidljive razlike u situacijsko-motoričkim testovima statistički značajne, a u korist dječaka. Najveća razlika u korist dječaka se očituje u disciplinama žongliranja lopte (SMFZ), vođenja lopte u slalomu (SMFVLS), snage udarca (SMFSU) i bacanja lopte u koš (SMKBLK). **Zaključak:** U ranijem periodu djetinjstva učenici su fizički aktivniji od većine učenica, a njihov "početak" se ogleda u tendenciji pobjeđivanja (želja za pobjedom), dok društveni motivi usmjereni ka poboljšanju vještina prevladavaju kod djevojčica. Potrebno je što više uključiti učenike u dodatne fizičke aktivnosti, a posebno u ovoj populaciji. Uprkos činjenici da je planirano tri časa sedmično, samo se jedan čas tjelesnog i zdravstvenog odgoja izvodi u sali tokom sedmice, a često i u neprikladnim uslovima. Željene promjene kod djece će vremenom nastati stvaranjem stalne navike bavljenja sportom.

Ključne riječi: razlike, rod, situacijsko-motorička sposobnost, fizičko obrazovanje, učenici

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IN-SERVICE TRAINING OF PRIMARY SCHOOL GENERALIST TEACHERS ON PHYSICAL AND SPORT EDUCATION: PERCEPTIONS AND PROPOSALS

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ABSTRACT

In Italy, teachers are obliged to perform compulsory, permanent and structural training under the responsibility of individual educational institutions. The aim was to understand the training needs of in-service teachers in primary schools in order to properly elaborate, through the analysis of primary school teachers' perceptions and in the light of the changes imposed by the management of the health emergency at a national level, the training planning. The aim was to collect and process data in order to define a training proposal that would meet the real needs of teachers in relation to ME, and with an eye on the new educational perspectives of face-to-face teaching. A questionnaire was administered via Google Forms to a sample of 42 primary school teachers (97.6% female) with an average age of 51.7 years old. Chi-square was used as a statistical tool. Interesting and significant data emerged on teachers' perceptions, which highlight the training needs inherent in movement education which should also be practiced outdoors. The generalist teachers did not feel trained at all in the specific field and, even when there was physical, movement and sports activity in their movement biography, they did not feel prepared. Satisfying these training needs produces positive effects for the physical, movement and sports development of primary school pupils and, conversely, also provides satisfaction on the part of generalist teachers in terms of personal cultural preparation and physical, movement and sports fitness. A virtuous circuit is thus activated consisting of good practices that, in addition to being functional to the educational-didactic processes, produce psycho-physical well-being that is reflected in professional performance.

Keywords: physical education, teachers' competencies, motor education (ME)

INTRODUCTION

In Italy, teachers are obliged to perform compulsory, permanent and structural training activities. Lifelong learning is a moral commitment for teachers, both because of the constant need for professional training and updating, with a view to lifelong learning, and because of the differences in initial training found in the teaching staff of Italian primary schools. Despite the fact that for some 20 years now, in order to teach in primary schools, it has been necessary to hold a degree in primary education science, many of the teachers who serve in primary schools have a teaching qualification obtained with a diploma issued by the old magister secondary school institutes: this produces a heterogeneity in the provision of educational services influenced by differences in initial training. It is one of the aspects to be considered in the design of courses to be addressed to in-service teachers in order to standardise the training levels of the latter to teachers with a degree in primary education sciences (D' Elia et al., 2021). The didactic and organisational structure of the Italian primary school is based on the teaching disciplines introduced by the ministerial programmes of 1985 and the innovative National Indications for the first cycle of education, which have been modified several times over the years and stabilised in the National Indications for the curriculum of the first cycle of education (Raiola, 2011). The primary school system is different from the preschool and secondary one. Throughout the week, the generalist teachers mostly work alone to teach individual teaching subjects, and co-presence (teaching by several teachers at the same time) is provided for a few hours for specific teaching needs and within the predetermined staffing of teachers. Primary school teachers are engaged in Italian, history, geography, mathematics, science, English, art, image, technology, physical education, music education, and civic education. It is a widespread habit to limit body, movement and sports experiences to the specific field without taking into account that natural recreational sports activities fully respond to ME, with the specific learning objectives and the targets for the development of competences, progress vertically for the different levels of education. They are:

1) The body and its relationship with space and time

2) Body language as a communicative-expressive mode

3) The game, sport, rules, and fair play

4) Health, well-being, prevention, and safety

These thematic cores contain specific knowledge that is not in the 'ropes' of generalist teachers. From these derive specific teaching practices and tools that are unfailingly lacking in teacher training. The disciplinary deficiencies and erroneous beliefs of teachers, inherent in the risks associated with the practice of movement and sports activities, highlight the need for more disciplinary preparation (D' Elia, 2020). The present study aimed at capturing the in-service teachers' training needs in order to adequately elaborate the training planning through the analysis of primary school teachers' perceptions and in the light of the changes imposed by the management. It was necessary to collect and process data in order to define a training proposal that responds to the training needs of teachers in relation to the discipline of ME (Raiola, 2017; Di Domenico et al., 2019ab; D'Elia et al., 2020). Specifically, the levels of physical activity practice achieved by teachers had to be investigated (Khan et al., 2020; Agostini et al., 2018; Niklasson et al., 2010; Fjørtoft, 2001; Goldfield et al., 2012).

MATERIALS AND METHODS

A questionnaire was administered via Google Forms to a sample of 42 primary school teachers (97.6% female) with an average age of 51.7 years old. Particular attention was paid to the specific difficulties that teachers encounter in performing indoor and outdoor movement education in their own premises, also considering that teachers' perceptions. The questionnaire consisted of 28 questions divided into the following sections:

- Demographic and anthropometric data
- Indoor and outdoor movement
- Practice (current and future) of outdoor classes
- Impact on movement of social distancing and activity limitation
- Perception of the importance of movement during COVID-19

Descriptive statistics were used to calculate the variables expressed as percentages. A Chi-square analysis was performed to analyse the association between the variables. Statistical significance was set at p value ≤ 0.05. Data analyses were performed using the Statistical Package for Social Science software (IBM SPSS Statistics for Windows, version 25.0. Armonk, NY).

RESULTS

Most of the teachers are partially active and mainly perform outdoor activities which are considered

safer than indoor activities. The restrictions seem to have quite affected the amount of movement which can have beneficial effects against COVID-19. A detailed description is shown in **Table 1.**

Table 1. Results as a percentage of teacher responses

How physically active are you?	23.8% are physically active 50% are partially active 26.2% are sedentary
Where do you perform physical or sports activity?	63.6% indoor 36.4% outdoor
How much have the restrictions resulting from the pandemic affected the amount/quality of physical activity you do?	17.1% not at all 48.8% fairly 34.1% a lot
With the current 'smart' configurations of work, study and social relationships, do you have more free time to devote to movement?	28.6% yes 71.4% no
Do you think that the practice of physical activity and sport can have beneficial effects against COVID-19?	70.7% yes 29.3% no
In this pandemic period, do you think it is safer to practise physical and sports activity?	9.5% indoor 90.5% outdoor
How important do you consider the practice of physical activity and/or sport in your daily life and for the achievement of primary school development goals?	88.1% in daily life 97.6% for the development goals in primary school
Have you ever participated in educational activities involving outdoor physical activity (in parks or natural environments)?	21.4% yes 78.6% no
Do you perform outdoor physical activity in your teaching activities?	7.1% yes 92.9% no
Do you think your training is adequate for outdoor physical activity?	64.3% yes 34.7% no

Significant association emerged from Chi-square between being physically active and perceptions regarding the adequacy of one's training for outdoor activity. The description is shown in **Table 2.**

Table 2. Association between being physically active and perceptions about training

		Are you physically active?			X^2; p
		No	Partially	Yes	
Do you think your training is adequate for outdoor movement activities?	No	9	15	3	6.49; < 0.02
	Yes	2	6	7	

A significant association emerged from Chi-square between the perceived importance of movement in everyday life and both the usefulness of the "methods and didactics of movement activity" course and the importance of outdoor activities in primary school. A detailed description is shown in **Table 3.**

Table 3. Association between movement and the utility of outdoor activity in primary school

		How important do you consider the practice of physical activity, motor activity and/or sports in your daily life?				X^2; p
		2	3	4	5	
How useful do you consider it, for the purposes of your training and as a future teacher, to study methods and didactics of movement activities?	1	0	0	0	1	23.76; < 0.01
	2	1	0	1	0	
	3	0	4	6	2	
	4	0	0	0	4	
	5	0	0	4	10	
How much importance do you attach to outdoor activities in the organisation of "Body, Movement and Sport" experiences in primary school?	2	1	0	1	0	17.84; < 0.01
	3	0	3	1	3	
	4	0	1	7	7	
	5	0	0	5	13	

Chi-square revealed a significant association between the perceived adequacy of one's training for outdoor activity and incidence of injuries during ME lesson (p = 0.00). The description is shown in **Table 4.**

Table 4. Association between the perceived adequacy of one's own formation for outdoor activity and injuries during movement education

		In your experience as a primary school teacher, have any injuries occurred during physical activity, motor activity and/or sport?		X^2; p
		Never	Sometimes	
Do you think your training is adequate for outdoor movement activities?	No	14	13	14.58; < 0.00
	Yes	15	0	

Chi-square revealed a significant association between perception on the safest place to perform movement activities in general and in schools (p = 0.00). A detailed description is shown in **Table 5.**

Table 5. Association between perception of safety environment and in schools related to movement

		Which activities provide more safety in your opinion:				X^2; p
		Indoor activities	Outdoor activities	Neither	Both outdoor and indoor activities	
In the school environment, you consider it safe to practice motor activities:	Outdoor	0	4	0	0	22.33; < 0.001
	Indoor	4	0	1	5	
	Unsafe	0	1	1	4	
	Both indoor and outdoor	1	2	1	18	

Chi-square revealed a significant association between the importance of outdoor activity for a safe return to school and perceptions of the impact of movement restrictions (p = 0.00), as shown in **Table 6.**

Table 6. Association between restriction on movement and safety movement outdoor in schools

		Which of the following restrictions most affects the performance of motor and sports activities?				X^2; *p*
		Closed gym and sports facilities	Social distancing	Restriction of circulation and home isolation	Suspension of sporting events	
Do you think that the increase in outdoor movement activities, especially in primary schools, can encourage the resumption of classroom activities?	No	5	5	14	0	9.04; < 0.01
	Yes	11	1	5	1	

DISCUSSION

The answers provided by the teachers (Table 1) showed that 23.8% are physically active in the sense that they reach the levels of physical activity recommended by the WHO, while 50% are partially active, i.e., they perform some activity but do not reach the recommended 150 minutes of physical activity, and 26.2% state that they are sedentary and do not engage in physical activity in their free time. This points to the need to encourage teachers to be more physically active both in their free time and during work, an activity that is structurally experiential (Raiola, 2015; Altavilla, 2016; D'Elia & D'Isanto, 2021) in that the organisational-didactic structure of the primary school should be based on the motor-sport experience, and therefore should offer diversified opportunities in the various fields of performance with the operational declination of the thematic nuclei of the National Indications closely connected to each other. When

asked about the places of practice, excluding the sedentary, it emerges that the activity is mainly performed in indoor environments, and in 36.4% of cases, in outdoor environments. This figure should also be read in relation to the availability of practice environments, which seems to be very large for indoor activities and significantly larger than for outdoor activities. As with the quantity of physical activity, new horizons should also be envisaged for the places of practice, proposing outdoor education as an elective educational practice in pre-school and primary school, combining experiential methodology with the optimisation of indoor and outdoor school spaces to amplify the meanings that the experience of the body, movement and sport can take on in the school context (Haug et al., 2010). It was also interesting to find that, in the face of the current and well-established smart configuration of work, which at school has been translated into distance learning with even more specific peculiarities and difficulties for the primary school segment, the teachers and educators declare that they do not have a greater amount of free time to devote to physical activity, except in 28.6% of cases, but the rather peculiar datum is that in this particular period, in 90.5% of cases, the practice of outdoor activities increases the perception of safety in performing physical activity. With proper training, this perception could encourage teachers and educators to do more activities in outdoor environments, also bridging some of the limitations of safety protocols in teaching, especially in primary schools. With regard to the value that teachers and educators place on physical activity and sport, the importance of activity in daily life emerges in 88.1% of cases and a high recognition of the contribution that the body, movement and sport make to the achievement of competence development goals at the end of primary school (Ernst, 2014). Teachers experience the importance of this field of knowledge on a daily basis, and the distance learning modality has highlighted this phenomenon even more, raising awareness of the importance of sensory-perceptual, motor and sport experience for the overall development of children (Gordon et al., 2013). It also emerges that teachers have little direct experience of outdoor practice, with only 21.4% stating that they have had training experiences in this sense; the data that, however, most of all highlights the need for specific training that raises awareness and makes teachers aware of the beneficial effects of outdoor education, concerns the practice of outdoor activities in primary school, with only 7% of teachers stating that they perform activities in outdoor environments. Finally, a perception emerges on the part of 34.7% of teachers that they are not adequately trained to design and conduct these types of activities. These last data guide us not only in the definition of training courses to be offered to in-service teachers, but also in the school organisation, so that schools can be more and more willing to welcome outdoor experiences. The statistical processing of the Chi-square test shows a relationship between being physically active and the perception on the adequacy of one's training to perform outdoor activities (Table 2). The majority of the partially active believe that their training is not adequate, compared to the majority of the active who believe it is. A relationship was found between the perception of the usefulness, for training purposes and as a future teacher, of studying the "methods and didactics of movement activities" and the perception on the importance of the practice of motor and sports activities in everyday life. The majority of those who consider the study of the "methods and didactics of motor activities" to be very useful also consider the practice of motor activity in everyday life to be very important (Table 3). Then, a relationship was found between the perception on the importance of the practice of motor and sports activities in everyday life and the perceptions of the importance in primary school of outdoor activities during experiences relating to "the body and movement. The majority of those who consider the study of the "methods and didactics of motor activities" to be very important for their education also consider the experience of outdoor activities of "the body, movement and sport" in primary school to be of such importance (Table 3). The 'body, movement and sport' represents the privileged field of knowledge in primary school, due to its ability to satisfy children's natural need for movement, to spontaneously bring out and develop the child's cognitive, affective-relational and social potential already through playful-motor-sports play. Physical education with the basic nuclei represents the natural course of the development of the body, movement and sport. Therefore, there was a relationship between the experience of injuries occurring during the performance of physical activity, movement and/or sport as a primary school teacher and the perception of the adequacy of one's training to be able to perform outdoor motor activities. All those who think that their training is adequate for outdoor activities have never experienced accidents in primary school, in contrast to those who have experienced them a few times (Table 4). Safety is a very important aspect of the teaching of motor activities: dynamic activities involve executive risks and the perceived inadequacy of one's own training in methods of teaching motor activities increases the teachers' fear of executive risks associated with the practice of motor activities with consequences for the quantity and quality (poor) of body and movement-based experiences that are offered in primary school. Furthermore, there was a relationship between the perception of the safest activity to perform on a personal level and the perception on the safest activity to perform in the school setting. Those who perceive, on a personal level, indoor, outdoor, nowhere, both types of activity as safer to do, also in the school setting, perceive indoor, outdoor, nowhere and both types of activity as safer, respectively (Table 5). Movement in the primary school period represents the highroad

through which the child develops its potential to function in the different domains; sensory-motor experiences are foundational to the self; through the elaboration of sensory-motor experience, the child develops its capacity for internalisation and representation, and structures its personality: his sense of self-esteem and self-efficacy, the ability to self-regulate, self-awareness, are just some of the personality traits that are structured through both spontaneous and structured movement activities and that lead to an awareness of one's own body, the physical, cognitive and affective basis of the movement experience that is experienced and processed in a constructive way (Gehris et al., 2015). Finally, there was a relationship between the perception of the type of restriction that most affects the performance of motor activities and the perception that the increase of outdoor motor activities, especially in primary school, may favour the resumption of teaching activities in presence. The majority of those for whom outdoor activities may not favour the resumption of teaching activities in presence believe that the restriction that most affects the performance of motor activities is the restriction of movement and home isolation, while for those who believe the opposite, the closure of gyms and sports facilities had the greatest effect (Table 6). The environment in which movement activities take place produces different psychophysical stresses in the subject according to the different characteristics of the environment itself; indoor and outdoor motor practice is therefore not equivalent. Traditionally, outdoor educational activities have not been widely practiced in Italian schools due to a lack of suitable outdoor spaces in school buildings and to a poor outdoor educational culture among teachers; consequently, physical education in its practical and experiential dimension has mainly taken place indoors; however, following the restrictions imposed at a national level for the containment of the COVID-19 pandemic (Raiola et al, 2020; Raiola & Aliberti, 2021), with regard to the practice of motor and sport activities in the various learning environments, the potential of outdoor environments has been 'rediscovered', as these environments offer greater opportunities for practice in compliance with the restrictions in force during the period of the health emergency and which to some extent persist even in the non-strictly emergency phases; this has resulted in the need for didactic-educational redesign and the experimentation of new practices in outdoor environments that outline new perspectives for outdoor physical education (Ernst, 2014; Kernan, 2010)

CONCLUSIONS

Interesting and significant data emerged on the perceptions of teachers, which completely point to the training needs inherent in physical and motor education which should also be practiced outdoors. The generalist teachers do not feel trained at all in the specific field and, even in the presence of physical, motor and sports activity in their motor biography, they do not feel prepared. The fulfilment of these training needs produces positive effects for the physical, motor and sporting development of primary school students and, conversely, also provides satisfaction on the part of generalist teachers in terms of personal cultural preparation and physical, motor and sporting fitness. A virtuous circuit is thus activated consisting of good practices that, in addition to being functional to the educational-didactic processes, produce psycho-physical well-being that is reflected in professional performance. The collected data also revealed specific training needs on the part of teachers in the field of the body, movement and sport in outdoor activities. The latter represent the crossroads of girls' and boys' growth, maturation and development experiences and can also become an opportunity for teachers to implement their levels of physical and sport activity, thus activating a virtuous circuit of good practices that, in addition to being functional, produce psycho-physical wellbeing as a driver of health education as well as education in other knowledge through movement and, therefore, on the cognitive sphere.

CONFLICTS OF INTEREST

The author declares no conflicts of interest.

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STRUČNO USAVRŠAVANJE UČITELJA OSNOVNIH ŠKOLA ZA TJELESNI ODGOJ I SPORTSKO OBRAZOVANJE: STAVOVI I PRIJEDLOZI

SAŽETAK

Učitelji u Italiji moraju pohađati obavezno, trajno i strukturno usavršavanje, a što je odgovornost svake obrazovne institucije. Cilj je bio razumjeti potrebe učitelja osnovnih škola za usavršavanjem kako bi se, analizom stavova učitelja osnovnih škola te imajući u vidu promjene koje nameće djelovanje u hitnim zdravstvenim situacijama na državnom nivou, isto pravilno planiralo. Podaci su prikupljeni i obrađeni u cilju definisanja prijedloga obuke koja će zadovoljiti stvarne potrebe učitelja u odnosu na tjelesni odgoj te imajući u vidu nove obrazovne perspektive izravnog podučavanja. Upitnik je proveden korištenjem Google Forms programa na uzorku od 42 učitelja osnovnih škola (97,6% ženskog spola) u dobi od 51,7 godina. Hi-kvadrat test je korišten kao statistički alat. Zanimljivi i značajni podaci su dobijeni o stavovima učitelja, a što naglašava potrebe za usavršavanjem koje su svojstvene tjelesnom odgoju koji bi trebalo izvoditi napolju. Učitelji smatraju da nisu obučeni u ovom specifičnom polju i da, čak i u slučaju postojanja tjelesne, sportske i aktivnosti kretanja u njihovoj biografiji, oni nisu spremni. Zadovoljavanje ovih potreba za usavršavanjem pozitivno utiče na fizički, sportski i razvoj kretanja učenika osnovnih škola te time također pruža osjećaj zadovoljstva za učitelje po pitanju lične kulturološke pripreme i fizičke, sportske i sposobnosti kretanja. Time se aktivira pozitivna dinamika koja se sastoji od dobrih praksi koje, uz funkcionalnost po pitanju obrazovnih i didaktičkih procesa, prouzrokuju psihofizičku dobrobit koja se ogleda u profesionalnoj izvedbi.

Ključne riječi: tjelesno obrazovanje, kompetencije učitelja, motoričko obrazovanje (ME)

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PRESENTATION OF DIFFERENCES IN SOME BASIC MORPHOLOGICAL, MOTOR AND SPECIFIC VARIABLES BETWEEN THE GROUP OF STUDENTS PRACTICING AND THE GROUP NOT PRACTICING BASKETBALL

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ABSTRACT

The study includes a sample consisting of two male groups aged 14-15, a group that practices and the group of students that do not play basketball.

Eight variables were applied in the morphological space, while in the basic and specific motor space, eight variables were also treated through the t-test method. In the morphological space as well as in the basic and specific motor space, valuable results were obtained for the basketball game between the two age groups, and the hypothesis put forward is fully realised. The results obtained as a whole are valid for the benefit of young people, given the adolescent age of these students.

Keywords: young basketball players, testing tools, sports equipment, morphological variables, basic and specific motor space variables

INTRODUCTION

As a sport, basketball is an attractive game that arouses curiosity in everyone regardless of age, gender, religion, etc. The game of basketball is valuable because it offers fun, but at the same time, requires and develops intelligence. The sport of basketball contains in itself a host of technical-tactical elements accompanied by complex exercises as well as various attractions on special occasions, offering visibility more than ever. Based on the research of transformational processes, the existence and

influence of many factors in the realisation of complex motor tasks, as well as the achievement of more advanced results in the sport of basketball are undoubtedly proven.

PURPOSE OF THE STUDY

The study-experiment in question includes the group of those who practice and the group of students who do not practice basketball. More specifically, the number of variables and the main objectives will be defined in achieving the following goal:

Confirmation of changes in the basic and specific motor space as well as in morphological variables between the group of students who practice and the group of students who do not practice basketball.

STUDY-EXPERIMENT HYPOTHESIS

In this study, the only hypothesis is foreseen to accurately confirm the prediction of the primary objectives for the realisation of the professional-scientific results of this experiment.

H1 - Assume that the differences between the group that practices and the group that does not practice basketball will be confirmed in the morphological variables as well as the variables in the basic and specific motor space, valid for the game of basketball.

THE SAMPLE OF TEST SUBJECTS

The study-experiment includes 80 subjects divided into two groups of males aged 14-15 years, the group of students who practice and the group of students who do not play basketball.

The group that deals with the sport of basketball exercises three times a week in basketball schools, and tests are conducted in sports gyms in the city of Pristina.

THE SAMPLE OF VARIABLES

The study-experiment includes eight variables from the basic-specific motor space, as well as eight morphological variables.

Morphological variables:

Body weight - ABWI
Body height - ABHE
Arm length - AALE
Leg length - ALLE
Palm length - APALE
Palm width - APAWI
The length of the sole of the foot - ATLSF
Toe width – ATOWID

Basic motor tests:

20m sprint - MFARU20m
Standing high jump - MHIJC
Standing long jump - MLOJC
Specific motor variables:
Free throws with the right hand - MFTHRH
Free throws with the left hand - MFTHLH
Back and forth dribbling - MBFDR
Agility test - MAGTE
Throwing the ball from a sitting position – MTHBSP

METHODS OF PROCESSING RESULTS

The results of the study and the hypothesis presented offer us the opportunity to select the most appropriate methods for conducting this study, using the appropriate program for data processing. The t-test method provides us with the confirmation of the differences between the two groups.

RESULTS AND DISCUSSION

Presenting the differences between the group that practices and the group that does not play basketball

T-test between basketball players and students in the morphological space

Table 1: Differences between basketball players and students in the morphological space

Variable	Sample	No.	Mean	Std. Dev.	Sig.
ABWI	Basketball	40	57.3947	8.76892	.286
	Students	40	55.2250	9.03409	
ABHE	Basketball	40	169.6368	9.43001	.082
	Students	40	166.0700	8.42135	
AALE	Basketball	40	73.8711	4.49768	.236
	Students	40	72.6450	4.56098	
ALLE	Basketball	40	21.5895	2.17390	.018
	Students	40	20.5825	1.46985	
APALE	Basketball	40	78.0263	4.45085	.186
	Students	40	79.5000	5.24771	
APAWI	Basketball	40	103.4684	5.56835	.083
	Students	40	101.3075	5.30802	
ATLSF	Basketball	40	25.7289	1.54813	.287
	Students	40	26.0925	1.44566	
ATOWID	Basketball	40	94.5526	4.94673	.253
	Students	40	93.2000	5.39801	

Based on the results obtained in amza.nr.1, we confirm the presentation of differences in the morphological space between two independent groups, such as: The group of those who practice and the group of those who do not play basketball. So, statistically significant differences in the morphological space were shown only by the variable of the palm length (ALPH) in the value of Sig = 0.018 in favour of the group practicing basketball, while in the other variables, both groups show approximately similar results.

Table 2: Differences between students and basketball players in the motor space

Variable	Sample	No.	Mean	Std. Dev.	Sig.
MFARU20m	Basketball	40	3.6982	.32528	.597
	Students	40	3.6640	.23850	
MHIJL	Basketball	40	166.5526	21.18732	.017
	Students	40	180.2500	27.57159	
MLOJC	Basketball	40	40.5263	7.14611	.704
	Students	40	41.1750	7.83119	
MFTHRH	Basketball	40	4.5789	2.11343	.000
	Students	40	2.3250	1.62335	
MFTHLH	Basketball	40	1.4474	1.22358	.001
	Students	40	.6500	.76962	
MBFDR	Basketball	40	8.6739	.74669	.000
	Students	40	9.2898	.68064	
MAGTE	Basketball	40	7.0153	.58827	.000
	Students	40	7.6730	.48493	
MTHBSP	Basketball	40	7.6737	1.36628	.102
	Students	40	7.1713	1.31584	

Based on the results obtained in amza.nr.2, we confirm the presentation of differences in the basic and specific motor space between two independent groups, such as: The group of those who practice and the group of those who do not practice basketball. So, statistically significant differences in the basic and specific motor space have been shown in all specific motor variables, such as: In the free throwing test MFTHRH, free throwing with the left hand MFTHLH, then, dribbling with the ball MDRB as well as in the MAGT agility test in favour of the basketball team, while in the explosive strength test - standing long jump MSLOJ, in the value of Sig = 0.017, it was in favour of the group of students practicing basketball.

HYPOTHESIS ANALYSIS AND VALIDATION

Based on the single hypothesis, the purpose of this study, based on the results obtained in the tables, shows the verification of the following hypothesis:

H1- The only hypothesis shows us the confirmation of the differences between the group of basketball players and the group of students (who do not play basketball) when it comes to the specific variables of the game of basketball. So, the hypothesis is realised entirely in the motor space but not in the morphological space.

CONCLUSION

Determining the treatment of the subjects from the two groups, the group that practices and the group of students that do not practice basketball, will be in function of advancing the transformational processes of the age in question, especially with validity in the basic and specific motor space.

Based on the application of scientific research methods of study, it shows us the best way as an information base in order to valorise programme values and contents during training processes.

Based on the results achieved in this study, it is somewhat valuable for basketball educators and coaches regarding the important information that presents motor skills in order to determine the volume and intensity of loads during training sessions.

The overview of the study shows that the full goal has been achieved, and the difference between the group of basketball players and the group of students who do not play basketball has been confirmed. Let us hope that this study-experiment will serve as an incentive for the advancement of future generations in basketball.

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PRIKAZ RAZLIKA U NEKIM OSNOVNIM MORFOLOŠKIM, MOTORIČKIM I SPECIFIČNIM VARIJABLAMA IZMEĐU GRUPE UČENIKA KOJI SE BAVE I GRUPE UČENIKA KOJI SE NE BAVE KOŠARKOM

SAŽETAK

Studija je obuhvatila uzorak koji se sastoji od dvije grupe muškog spola u dobi od 14 do 15 godina, grupe koja se bavi košarkom i grupe učenika koji ne igraju košarku.

Osam varijabli je primijenjeno u morfološkom prostoru, dok je u osnovnom i specifičnom motoričkom prostoru također korišteno osam varijabli putem metode t-testa. Korisni rezultati su dobijeni u morfološkom kao i osnovnom i specifičnom motoričkom prostoru košarkaške igre između dvije dobne grupe, a predstavljena hipoteza je u potpunosti realizovana. Dobijeni rezultati su u potpunosti valjani u korist omladine s obzirom na adolescentsko doba ovih učenika.

Ključne riječi: mladi košarkaši, alati za testiranje, sportska oprema, morfološke varijable, osnovne i specifične motoričke varijable

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ANALYSIS OF OUT-OF-SCHOOL SPORTS PRACTICE IN SPANISH CHILDREN AGED 6 TO 12 YEARS OLD

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ABSTRACT

Background: The change of habits in the occupation of young people's leisure time in the Spanish society has led to an increase in sedentary activities, as opposed to physical and sporting activities outside the school context. The occupation of leisure time in motor activities not only favours health, as indicated by important institutions, such as the World Health Organisation, but they are also fundamental for motor, psychological, social, and affective development. **Aim:** The main objective of this research is to analyse the levels of extracurricular sports practice on a sample of Spanish children. **Methods:** A descriptive, cross-sectional, quantitative study was carried out. An ad hoc validated questionnaire was used to collect the data. **Results:** The results obtained show that a large part of the infant-juvenile population (71.6%) participates in federated sport; however, the average number of days spent practicing sports does not exceed 3.37 days. Differences in participation were found in terms of gender, with a predominance of team activities in the case of boys and individual activities in the case of girls. A 22.5% overweight and obesity rate was also found, with higher values in boys. **Conclusion:** The levels of extracurricular sport practice are higher in boys than in girls, with differences also found in the type of sport practised in relation to gender, with football being more predominant in boys and basketball and gymnastics in girls.

Keywords: primary education, physical and sporting activity, extracurricular activities

INTRODUCTION

Currently, young people spend a large number of hours sitting or doing sedentary activities, not only in school, but also outside of it, either doing homework or leisure activities. Despite the fact that the educational sphere promotes and favours collaborative work as a methodological strategy that facilitates learning (Sagredo et al., 2020), the educational institution sometimes gives students numerous responsibilities that unconsciously submerge them in a competitive environment (Venga, 2020).

Within this framework, it is worth highlighting the importance of physical and sporting activity which, according to Gutiérrez (2004), in addition to favouring motor development, has social and psychological repercussions. Despite all the benefits of physical activity and sport (PSA), the current lifestyle of young people is characterised by "sedentary lifestyles, stress, tobacco, alcohol, and drug consumption, diet and more hours of television" (Montil et al., 2004).

The World Health Organisation (WHO) (2020) recommends at least 60 minutes of moderate to vigorous intensity aerobic physical activity every day and at least three days a week of vigorous intensity aerobic activities, as well as activities that strengthen muscles and bones. It is also advisable to reduce the time reserved for sedentary activities, and with particular relevance to the time that people in this age group spend during their leisure time using screen-based technologies (WHO, 2020).

According to the National Health Survey (ENSE), carried out in Spain in 2017 by the National Statistics Institute (INE), 14% of children spend their leisure time in an almost totally sedentary way. Moreover, 73.9% of this group spends at least one hour of their leisure time in front of screens every day. Along the same lines, the PASOS study carried out by the Gasol Foundation (2019) shows that only 36.7% of the Spanish population between 8 and 16 years of age follows the physical activity recommendations given by the WHO. The decrease in DFA increases as the age of the subjects increases and is greater in girls. On the other hand, Rodríguez-Fernández et al. (2021) have carried out a recent study in Galicia in which they state that 86.4% of pupils aged between 10 and 12 years perform regular voluntary physical activity, coinciding in the fact that females practice a lower amount of voluntary physical activity.

Another noteworthy fact is the decrease in the levels of physical activity recorded as school age increases, with a decrease in physical activity in 12-year-olds compared to 11-year-olds, and 11-year-olds compared to 10-year-olds (Navarro-Patón et al., 2021). The highest sedentary behaviour was found in boys and girls aged between 12 and 14 years (García-Soidán et al., 2020).

According to Nuviala and Nuviala (2005), some of the reasons for dropping out of sport have to do with lack of interest, poor supply or lack of peers. However, the main motivation for taking up PES is mainly generated by parents, and the younger the children are, the greater the influence. Even so, the media also have an impact on DFA in the general population (Latorre et al. 2009). In addition to the relationship between the DFA habits of parents and offspring, joint activities between parents and offspring are an important factor in the creation and establishment of lifelong healthy habits (Castillo et al., 2018).

It should be noted that the above data worsened during the period of home confinement as a measure to prevent the spread of the SARS-CoV-2 virus in the Spanish population (Ramos et al., 2021). This measure led to a change in habits that reduced the number of hours dedicated to the practice of DFA outside the educational context as well as its frequency, with a consequent worsening of their levels of physical fitness.

AIM

The main objective is to determine the levels of sport practice in the out-of-school environment of children between 6 and 12 years of age. Additionally, the study analysed the difference between these levels in terms of gender.

METHODOLOGY

Study design and sample

A descriptive, cross-sectional, quantitative study was carried out. For this purpose, a questionnaire called NYCAFIN (The Levels and Quality of Physical Activity in Infancy and Childhood) was designed ad hoc to collect the levels of physical activity practice of the population from three to twelve years of age in different scenarios: school, out-of-school, family, and social settings.

The study population consisted of Spanish families with children between the ages of six and twelve, from which a sample of 285 children was obtained. The distribution of the sample according to the sex of the participants was 48.8% girls and 51.2% boys. The sample was selected by convenience. The sample was 8.8 years old at the time of data collection (SD: ± 2.2).

In order to estimate the sample size, the latest data published by the Ministry of Education and Vocational Training of the Spanish Government (2022) were used in relation to schooling in primary education, with a total of 2,7927,597 children throughout Spain. With a confidence level of 90% and a margin of error of 5%, the sample size was 273 subjects, resulting in a total of 285 subjects in this study. The participating subjects are enrolled in public, state-subsidised and/or private primary schools in Spain.

Data collection instrument and variables

For data collection, a questionnaire based on validated questionnaires such as the APALQ, YACH or PAQ-C

has been developed. This questionnaire is called Levels and Quality of Physical Activity in Childhood and Infancy (NYCAFIN). For content validation, a panel of experts composed of six professionals in the field of physical activity and infancy and childhood was convened. The experts evaluated each item of the questionnaire in terms of relevance, clarity and representativeness of the dimensions to be measured. In addition, their feedback was solicited and modifications were made to the questionnaire according to their recommendations.

After a brief introduction, which includes the informed consent to fill in the questionnaire and some brief guidelines for completing the questionnaire, a series of socio-demographic data (date of birth, age, sex, current grade of primary education, height, and weight) are requested to be filled in.

Subsequently, a record was made of physical activity in the different areas of the daily life of primary school pupils within the school context: in Physical Education classes, breaks and playgrounds, active breaks, and physical activity programmes. In the out-of-school context, and focusing on federated sport, information was obtained on the sport practised and whether they participate in competitions, also measuring the weekly frequency (number of times per week a given activity is carried out), daily time (measured in minutes) and intensity of physical activity (on a scale of 1 to 4, with 1 corresponding to mild intensity, 2 to moderate, 3 to intense or vigorous and 4 to very intense or very vigorous).

PROCEDURE

The questionnaire was distributed in two ways. The first was to send the questionnaire online to teachers in several schools in a region in the north of Spain so that they could distribute it to the families in their schools. These schools were public, state-subsidised and private schools in urban, semi-urban and rural areas.

On the other hand, it was distributed through two social networks: Facebook and Twitter, being shared in groups and pages linked to the education of primary school children.

The questionnaire was disseminated for 30 days, between 1st April and 30th April 2022

ETHICAL ASPECTS

Throughout the research, the ethical principles reflected in various official documents, and treaties on research ethics were taken into consideration, guaranteeing the anonymity of participants, confidentiality of data and other ethical considerations related to research in education (American Psychological Association, 2020; Sañudo, 2006).

DATA ANALYSIS

In the descriptive analysis, the characteristics of the participants were determined using the mean (M), standard deviation (SD) and frequencies (%). For the data analysis, we first used a data dump from Google Forms to Excel and then from Excel to the statistical program SPSS 28.0. All data were cleaned during filtering.

RESULTS

In relation to the results obtained for the anthropometric variables, the values of weight, height and BMI were obtained from the sample (Table 1):

Table 1: Average weight, height, age, and BMI

Weight (in kilogrammes)	Height (in cm)	BMI
33.4 ± 9.6	137.2 ± 13	17.5 ± 2.7

Note: Data presented in mean and standard deviation.

The sample was categorised according to their weight and the recommended percentiles for their age (Table 2), with the following results:

Table 2 : Underweight, normal weight, overweight or obese students

	Boys	Girls	Total
Underweight	3.4%	5.8%	4.6%
Normal weight	69.9%	76.2%	72.9 %
Overweight	16.4%	15.1%	15.8%
Obese	10.3%	2.9%	6.7%

With reference to the characteristics of the educational centres, 170 subjects studied primary education in public schools (60%), 106 in state-subsidised schools (37%) and 9 in private schools (3%). Likewise, the distribution of the sample according to the location of

the centre was 206 students (72%) who attended an educational centre in an urban environment, 63 (22%) in a semi-urban environment, while 16 (6%) attended school in a rural environment.

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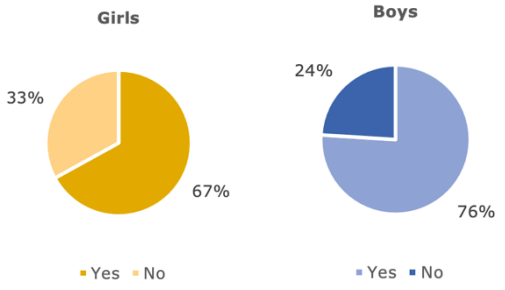
Outcomes of physical activity levels in the out-of-school environment

The results related to the practice of federated sport in the out-of-school environment show that 28.4% of the total sample does not practise any type of federated sporting activity, compared to 71.6% of the sample that does practise some type of federated sporting activity. In addition, out of this percentage who practice some kind of sport, there are more boys in the sample who practice some kind of federated sport than girls, 54% of boys compared to 46% of girls.

These data according to gender show that 76% of boys do sport in their free time. However, this figure drops by 9% in the case of girls (Figure 1).

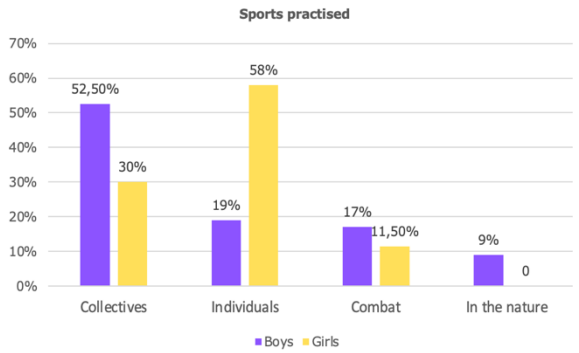
Figure 1 : Federated sports practice in boys and girls



For the analysis of the type of sport they practise, the decision was taken to group them according to the classification of Durand (1968, in Martín-Albo et al., 2002), who proposed a grouping of sports into categories according to the teaching-learning situation. Thus, the categories established are individual sports, collective sports, combat sports, and outdoor sports.

According to this classification, Figure 2 shows that boys prefer to play collective sports, while girls choose individual sports. Combat sports are more equally represented, although they are slightly preferred by boys. Outdoor sports are the least practised in general terms, with only boys opting for this type of sport.

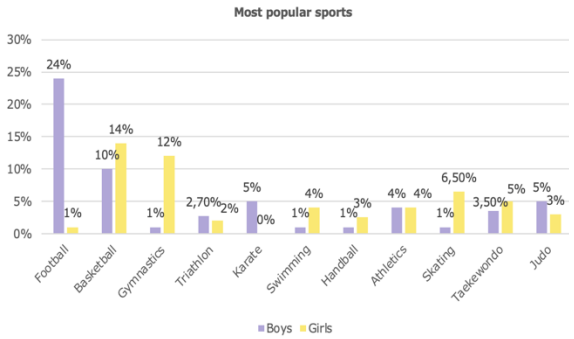
Figure 2 : Sports practised according to Durand's classification (1968)



Note. The purple colour illustrates the results of the male gender and the yellow colour illustrates the results of the female gender

Figure 3 shows the federated sports with the highest number of participants.

Figure 3: Sports most practised by pupils



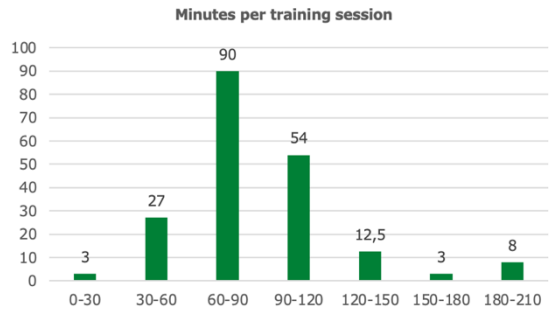
Note. The purple colour represents boys and the yellow colour represents girls.

In terms of the frequency of workouts performed calculated in days/week, the mean is 3.37 (SD: ± 5.2) days per week. However, most of the young people exercise two days per week (Figure 4).

Figure 4: Weekly training days

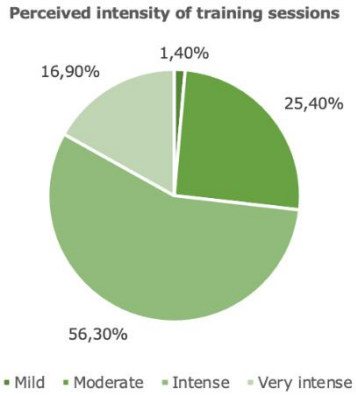
These workouts have a mean duration of 77.6 (SD: ± 32.3) minutes. As shown in Figure 5, the majority of the sample studied have workouts whose duration varies between 60 and 90 minutes per session. However, there are cases where the duration is less than half an hour and others where it exceeds 180 minutes.

Figure 5: Minutes per training session



In relation to the results obtained from the intensity of the training sessions (Figure 6), 56.3% perceive the load of the sessions as intense, 25.4% say that it is moderate and 16.9% feel that it is very intense. Only 1.4% perceived it as light.

Figure 6: Perceived intensity of training sessions



Finally, 70% of the sample, in addition to training, participate in federated competitions, compared to 30% who only attend training sessions.

DISCUSSION

With regard to the number of students who practice federated sport, it was found that almost three quarters of students (71.6%) practice federated sport in their free time, a higher percentage than other studies such as those carried out by Luengo (2007) and Reverter et al. (2014), although lower than that developed by Sánchez-Urrea et al. (2019), who reflect that 76% of their sample does practice sport or the 90% reached in another study with Spanish children (Chacón et al., 2017). It should be noted that, according to data obtained in other studies (Luengo, 2007; Latorre et al., 2009; Sánchez-Urrea et al., 2019; Zurita-Ortega et al., 2018 and Reverter et al., 2014), the number of boys who devote their extracurricular time to sport is higher than girls (54% versus 46% in this study). For this reason, there is a need to develop programmes and initiatives aimed at promoting the practice of sport among young girls, such as increasing the visibility of female athletes in sporting events so that girls will have a visible reference point or reducing the negative stereotypes held towards them (Poll, 2021).

With regard to the type of physical exercise practised, it should be noted that boys show a clear preference for group sports, while individual sports are selected by girls. These differences may be determined by the type of goals pursued by individuals according to gender. While males seek fun, competition, contact, and body strength, females strive for a desired body image or health maintenance, the latter being associated with individual sports, while the former are linked to team sports (Chacón et al., 2016; Isorna et al., 2014). Moreover, the type of motivation is of utmost importance in the selection of activities, as well as in the involvement in them (Isorna et al., 2014). Further research on the motivations that determine sport practice among girls would be advisable.

Among boys, the sports most practised by boys are football, basketball and karate, in contrast to girls, who choose basketball, gymnastics and skating. Therefore, it can be seen that boys opt for team sports as in other studies (Luengo, 2007; Reverter et al., 2014) and combat or contact sports (Luego, 2007). On the other hand, as reported by Reverter et al. (2014), girls prefer to practice basketball or individual activities (Luengo, 2007).

In reference to the frequency of training, most of the subjects attend their training sessions two days a week, followed by three days, results similar to those extracted by Reverter et al. (2014) or Sánchez-Urrea et al. (2019) who reflect that almost half (48%) of their sample practice physical activity three days a week or Luengo (2007), as in his case the majority of his respondents (92.1%) attend their training sessions two days a week. There is an equality between students who attend one, four or five days of their activity, while others attend six or seven days, although this percentage represents a minority. In the latter case, although no concrete limits have been established between the amount of physical exercise that is healthy and that which can be counterproductive in young athletes, it is advisable to pay attention to this high frequency of training in order to avoid different types

of injuries derived from overtraining or overuse of any musculoskeletal structure (Brenner, 2007).

The average time of each of these training sessions is about 77.6 (SD: ± 32.3) minutes, so most of the athletes exercise between sixty and ninety minutes each time they attend their training session, which coincides with the studies of Luengo (2007), as most of his sample trains between one and two hours in each session.

In turn, as reflected by Reverter et al. (2014), more than half of the students who engage in physical-sports practice participate in some type of competition, with 70% of those surveyed in this study doing so.

The results of this study should be taken into consideration in a prudent manner and not extrapolated to the world population.

CONCLUSIONS

Through this research, it is concluded that 3 out of 10 children do not practice any extracurricular sport, with around 25% being overweight and/or obese, and more boys than girls. There are also differences in terms of gender and sporting practice, with boys playing more sport than girls, and girls preferring certain sports, such as gymnastics, basketball or skating, as opposed to football, basketball or karate, which predominates among boys. Educational and sports policies are needed to promote equal participation of boys and girls in all sports, increasing the levels of practice.

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ANALIZA BAVLJENJA SPORTOM IZVAN ŠKOLE KOD ŠPANSKE DJECE U DOBI OD 6 DO 12 GODINA

SAŽETAK

Kontekst: Promjena navika u načinu provođenja slobodnog vremena kod mladih ljudi u Španiji je dovela do povećanja sjedilačkih aktivnosti nasuprot fizičkim i sportskim aktivnostima izvan školske sredine. Bavljenje motoričkim aktivnostima tokom slobodnog vremena ne samo da pogoduje zdravlju, a na što ukazuju važne institucije poput Svjetske zdravstvene organizacije, nego je također i ključno za motorički, psihološki, socijalni i afektivni razvoj. **Cilj:** Glavni cilj ovog istraživanja je analizirati nivoe vannastavnog bavljenja sportom na uzorku španske djece. **Metode:** Provedena je deskriptivna, transverzalna i kvantitativna studija. Za prikupljanje podataka je korišten važeći ad hoc upitnik. **Rezultati:** Dobijeni rezultati pokazuju da veliki udio populacije djece i omladine (71,6%) učestvuje u organizovanom sportu. Međutim, prosječan broj dana koji oni provode u bavljenju sportom ne prelazi 3,37 dana. Razlike u učešću su pronađene po pitanju spola uz prevladavanje timskih aktivnosti kod dječaka te individualnih aktivnosti kod djevojčica. Stopa prekomjerne težine i pretilosti od 22,5% je također otkrivena, a vrijednosti su više kod dječaka. **Zaključak:** Nivoi vannastavnog bavljenja sportom su viši kod dječaka nego kod djevojčica, a razlike su također pronađene u vrsti sporta kojim se bave po pitanju spola gdje fudbal prevladava kod dječaka, a košarka i gimnastika kod djevojčica.

Ključne riječi: osnovno obrazovanje, fizičke i sportske aktivnosti, vannastavne aktivnosti

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THE EFFECT OF ONLINE EXERCISE INTERVENTION ON PSYCHOLOGICAL FACTORS IN UNIVERSITY STUDENTS DURING THE COVID-19 PANDEMIC

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ABSTRACT

Background and Study Aim: Stay-at-home and other pandemic-related measures taken by governments to combat the COVID-19 pandemic undoubtedly limited the movement that individuals were used to following, disrupting their daily routines. This research aimed to examine the effect of online exercise intervention on sedentary students during the COVID-19 pandemic. **Material and Methods:** This experimental research is conducted with pre- and post-test repeated measure design. 76 female students (age = 21.70 ± 1.48) voluntarily participated in the study, and they were selected by the convenient sampling method. The intervention programme includes 12 weeks of exercise participation. While the experimental group was included in the exercise intervention, the control group participants did not receive any exercise intervention. The Short Version of the Psychological Resilience Scale (PRS) and Burnout Measure - Short Version (BMS) were used to measure the psychological parameters of the participants. In addition, Speilberger's Trait Anxiety Scale was used to determine the anxiety traits of the participants. **Results:** There were no statistically significant differences between the experimental and control groups in psychological resilience ($t(74) = -.393$, $p > .05$), burnout ($t(74) = -.545$, $p > .05$) and anxiety ($t(74) = -.484$, $p > .05$) scores. The one-way analysis of covariance (ANCOVA) had been performed when the pre-test scores were adjusted as covariance. **Conclusions:** There are numerous implications and limitations when considering the results of this study. First, it should be accounted for that conducting online exercise interventions cannot be ruled out as face-to-face sessions. This is one of the greatest and most important limitation of this study.

Keywords: COVID-19, physical activity, exercise and sports psychology, exercise intervention

INTRODUCTION

The COVID-19 pandemic has ushered in a cascade of lifestyle disruptions and psychological stressors, leaving a particularly lasting impression on university students at a global level (Ammar et al., 2020; Balboa-Castillo, León-Muñoz, Graciani, Rodríguez-Artalejo, & Guallar-Castillón, 2011).

With universities transitioning to online education, the absence of structured campus life has exacerbated the sedentary lifestyle which has been previously identified as a risk factor for various adverse health outcomes, including psychological well-being (Nadeem, Qazi, Batool, & Naseer, 2023; Tran et al., 2021). Research highlights the potential benefits of physical activity on psychological health, including reducing stress and improving emotional well-being (Wahjuni, Febriyanti, Yuhantini, & Rosyida, 2022)

Yet, the closure of gyms, parks and recreational centres due to pandemic-related restrictions has limited traditional avenues for physical activity (Bertrand et al., 2021; López-Valenciano, Suárez-Iglesias, Sanchez-Lastra, & Ayán, 2021; Rogowska et al., 2020)

This limitation is of particular concern for university students who have reported increased rates of stress and anxiety during the pandemic (Babicka-Wirkus, Wirkus, Stasiak, & Kozłowski, 2021; Son, Hegde, Smith, Wang, & Sasangohar, 2020; Wang et al., 2020). Despite an array of studies examining the beneficial effects of physical activity, there is a noticeable gap in the literature concerning its impact in an online environment tailored for university students during the pandemic (Alexander & Shareck, 2021; Wilson, Holland, Elliott, Duffey, & Bopp, 2021). This is especially relevant given the rapid shift to online education and its long-term psychological implications, often termed the "Covid Generation"(Liu, Pinder-Amaker, Hahm, & Chen, 2022). This study aims to fill this research gap by investigating the effectiveness of an online exercise intervention in enhancing psychological health among university students who have transitioned to online education due to the COVID-19 pandemic. We seek to provide empirical evidence on whether such interventions can act as a robust tool for mitigating the psychological distress experienced during these unprecedented times.

MATERIAL AND METHODS

This study employs a pre- and post-test repeated measures design, which allows for a focus on assessing changes over time (Jiménez-Pavón, Carbonell-Baeza, & Lavie, 2020). Two groups are included: an experimental group subjected to a 12-week exercise programme and a control group without any intervention. The participants included 76 university students who volunteered for the study. Eligibility criteria required participants to lack recent physical activity and to hold no current gym or sports club memberships. Random assignment was conducted based on the last four digits of their student IDs. Both the exercise trainer and participants were double-blinded for the study's integrity. Questionnaires: The Burnout Measure Short Version (BMS) (Malach-Pines, 2005) and Spielberger's Trait Anxiety Scale (Spielberger, Gonzalez-Reigosa, Martinez-Urrutia, Natalicio, & Natalicio, 1971) were used. Physical Assessments: Self-reported height and weight were collected for BMI calculation (Bhutani, Cooper, & Vandellen, 2021; Navarro-Cruz et al., 2021). Psychological Resilience: The Psychological Resilience Scale Short Version (PRSV) was used for the assessment (Franušić, 2021; Kamšigovski, 2022). The 12-week intervention consisted of callisthenic exercises adjusted based on individual physical capacities. The programme's intensity was moderated in the latter six weeks based on observed physical improvements. Exercise sessions were conducted online and monitored to ensure participant safety. Participants with existing health issues were advised to abstain. Informed consent was obtained online, in accordance with best practices for protecting participant privacy. Primary outcomes include changes in burnout, anxiety and psychological resilience levels. Secondary outcomes examine changes in BMI.

STATISTICAL ANALYSES

An a priori power analysis using G*Power was executed to identify the required sample size. A power level of 1-ꞵ = 80%, α= 0.05 and Cohen's d = 0.04 were set as parameters (Faul, Erdfelder, Buchner, & Lang, 2009). The analysis indicated that 64 participants would be adequate for ANCOVA tests. Taking into account potential dropouts due to the pandemic conditions, as suggested by Suresh and Chandrashekara (2012), the sample size was increased by 10%, resulting in a total of 90 participants. The study commenced with 90 participants equally divided between the experimental and control groups (n = 45 each). However, due to health-related withdrawals, seven participants from both groups exited the study. The final analysis was conducted with 76 participants (n = 38 for the experimental group and n = 38 for the control group). Preliminary analyses included a check for outliers using Mahalanobis distances, confirming the absence of any outliers (De Maesschalck, Jouan-Rimbaud, & Massart, 2000). Subsequently, the data were examined for normality. Skewness and kurtosis indices fell within the -1.5 to +1.5 range, aligning with norms established by Tabachnick et al., 2007, confirming data normality. Independent Sample

T-tests: The t-tests were utilised for comparing pre-test scores between the experimental and control groups (Snedecor & Cochran, 1989). ANCOVA: Post-test scores for the experimental and control groups were analysed using one-way ANCOVA, with pre-test scores on psychological resilience, burnout and anxiety set as covariates (Maxwell, Delaney, & Manheimer, 1985). Prior to ANCOVA, assumptions such as independence and reliability of observations, homogeneity of variance and data normality were verified in accordance with Maxwell, Delaney and Manheimer (1985) and Miller and Chapman (2001). All assumptions were met.

RESULTS

Table 1: Comparison of t-test results of the pre-test scores between groups

Variable	Group	N	Mean	SD	t	df	p
Psychological Resilience	Experimental Group	38	20.34	5.92			
	Control Group	38	20.81	4.48	-.393	74	.696
Burnout	Experimental Group	38	39.84	9.22			
	Control Group	38	41.18	12.04	-.545	74	.587
Anxiety	Experimental Group	38	51.60	5.85			
	Control Group	38	52.21	5.00	-.484	74	

There were no statistically significant differences between the experimental and control groups in psychological resilience ($t(74) = -.393$, $p > .05$), burnout ($t(74) = -.545$, $p > .05$), and anxiety ($t(74) = -.484$, $p > .05$) scores. The one-way analysis of covariance (ANCOVA) had been performed when the pre-test scores were adjusted as covariance. The results of this analysis are presented in Tables 2 and 3.

Table 2: ANCOVA analysis results regarding the comparison of post-test psychological resilience scores adjusted according to experimental and control group pre-test scores

Variable	Sum of Squares	df	Mean Square	F	p	η^2
Psychological Resilience	22.701	1	22.701	2.072	.154	.028
Group	106.604	1	106.604	9.731	**.003**	.118
Error	799.720	73	10.955			
Sum	41322.000	76				
Adjusted Sum	933.789	75				

Experimental group post-test adjusted mean = 24.23; Control group post-test adjusted mean = 21.86

Table 4 shows that there was a statistically significant difference in post-test scores between groups in favour of the experimental group. The psychological resilience score of the experimental group ($F(1-73) = 9.731$, $p < 0.05$) was found to be higher after covariance was adjusted according to the pre-test scores. This result has shown that the psychological resilience level of the participants changed significantly from pre- to post-test following the intervention. In addition, eta-squared (η^2) was found to be .118. Based on this result, 12% of the change in the dependent variable occurred due to the intervention effect.

Table 3: ANCOVA analysis results regarding the comparison of post-test burnout scores adjusted according to experimental and control group pre-test scores

Variable	Sum of Squares	df	Mean Square	F	p	η^2
Burnout Pre-Test	1973.585	1	1973.585	18.714	.000	.204
Group	2218.560	1	2218.560	21.037	**.000**	.224
Error	7698.679	73	105.461			
Total	116662.000	76				
Corrected Total	12173.526	75				

Experimental group post-test corrected mean = 31.66; Control group post-test corrected mean = 42.49

The ANCOVA analyses showed that there was a statistically significant difference in favour of the experimental group between post-test burnout score means corrected according to experimental and control group pre-test scores ($F_{(1-73)} = 21.037, p < 0.05$). This result has shown that the burnout levels of the participants change significantly depending on the experimental method (callisthenic exercise). Moreover, eta-squared (η^2) was found to be .224. In that case, the experimental method applied to the groups shows that 22% of the change in the dependent variable is due to the applied method.

DISCUSSION

The COVID-19 pandemic has significant repercussions for both physical and mental well-being. This study aimed to explore the impact of an online callisthenic exercise programme on students' psychological resilience, burnout and anxiety during the pandemic. Seventy-six participants, divided equally into control and experimental groups, were recruited for the study. The pre-test scores revealed no significant differences between the control and experimental groups in terms of psychological resilience, burnout and anxiety. This homogeneity provided a robust foundation for interpreting the effects of the intervention (Glaser et al., 2022; Zammitti, Russo, Ginevra, & Magnano, 2023). Post-intervention, the experimental group displayed a significant improvement in psychological resilience when compared to the control group. These findings are in line with recent literature (Düzen, 2022) supporting the efficacy of regular exercise in enhancing resilience (Bayrakdaroğlu, 2014; Ghaderi & Ghaderi, 2012; Martinek & Hellison, 1997).

A significant decline in burnout scores was also observed in the experimental group. This is consistent with (Joseph, Royse, Benitez, & Pekmezi, 2014) who found that diverse forms of exercise could alleviate burnout symptoms (Balboa-Castillo et al., 2011; Batty & Lee, 2002). Contrary to expectations, the exercise intervention did not yield a significant decrease in anxiety scores. This contradicts existing research (Lindwall & Lindgren, 2005; Özdemir, 2010) possibly due to unique challenges posed by the pandemic. Other studies also noted increased physical inactivity during COVID-19 (Chtourou et al., 2020; Fuentes-García, Martínez Patiño, Villafaina, & Clemente-Suárez, 2020; Jiménez-Pavón et al., 2020). Our results suggest that online exercise interventions might not be as effective in reducing anxiety as in-person sessions. The limitations of our study include not being able to assess participants' physical abilities and a lack of familiarity with online exercise environments (Brand, Timme, & Nosrat, 2020). Further research is needed to explore these variables in-depth. While our intervention significantly impacted psychological resilience and burnout, its effects on anxiety were not conclusive. Future research should explore the limitations and adaptabilities of online exercise interventions for psychological well-being during uncertain times like the COVID-19 pandemic.

CONCLUSIONS

Our study provides valuable insights into the effects of an online exercise intervention on psychological resilience, burnout and anxiety during the strict home confinements brought about by the COVID-19 pandemic. However, several limitations must be considered when interpreting our results. Notably, the online nature of the intervention potentially impacts its efficacy in ways that differ from face-to-face sessions. Our findings also apply to women, as men represented only 5% of our sample. Another limitation is the reliance on self-reported data, which could introduce bias. Despite these limitations, our research has the distinction of being one of the first studies to explore online exercise interventions during a pandemic, offering a practical solution when face-to-face interventions were not feasible. The timing of the intervention — right after lessons — also served as a motivation factor for ongoing participation. Future research should consider these limitations

and examine the gender differences in similar study designs. More nuanced methods of psychological measurement could also be beneficial. Given the unprecedented challenges posed by the pandemic, we recommend that practitioners delivering online interventions weigh both the advantages and disadvantages, while also considering alternative outdoor activities and regular physical activity setups as conditions permit. The data supporting this study are available upon request due to privacy considerations.

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EFEKAT ONLINE INTERVENCIJSKIH VJEŽBI NA PSIHOLOŠKE FAKTORE KOD STUDENATA NA UNIVERZITETIMA TOKOM PANDEMIJE COVID-19

SAŽETAK

Kontekst i cilj studije: Ostanak kod kuće i druge srodne pandemijske mjere koje su vlade poduzele kako bi se borile sa pandemijom COVID-19 zasigurno su ograničile kretanje na koje su pojedinci navikli te omele njihove dnevne rutine. Ovo istraživanje je nastojalo ispitati efekat online intervencijskih vježbi na studente koji vode sjedilački način života, a tokom pandemije COVID-19. **Materijal i metode:** Ovo eksperimentalno istraživanje je provedeno uz dizajn ponovljenih mjerenja prije i poslije testiranja. 76 studentica (dob = 21,70 ± 1,48) je dobrovoljno učestvovalo u ovoj studiji te je odabrano metodom prigodnog uzorka. Intervencijski program obuhvata 12 sedmica vježbanja. Dok je eksperimentalna grupa učestvovala u intervencijskom vježbanju, učesnici kontrolne grupe nisu podvrgnuti intervencijskom vježbanju. Skraćena verzija Skale psihološke otpornosti (PRS) te Mjera iscrpljenosti - skraćena verzija (BMS) su korištene za mjerenje psiholoških parametara učesnika. Nadalje, Speilbergerova Skala anksioznosti kao osobine je korištena za utvrđivanje osobina anksioznosti kod učesnika. **Rezultati:** Statistički značajne razlike nisu pronađene između rezultata eksperimentalne i kontrolne grupe za psihološku otpornost (t(74) = -,393, p > ,05), iscrpljenost (t(74) = -,545, p > ,05) i anksioznost (t(74) = -,484, p > ,05). Jednostruka analiza kovarijanse (ANCOVA) je izvršena kada su rezultati predtestiranja podešeni kao kovarijansa. **Zaključci:** Postoje brojne implikacije i ograničenja kada razmatramo rezultate ove studije. Najprije bi se trebalo ukazati da se provođenje online intervencijskih vježbi ne može smatrati vježbama uživo. Ovo je najveće i najvažnije ograničenje ove studije.

Ključne riječi: COVID-19, fizička aktivnost, vježbanje i sportska psihologija, intervencijske vježbe

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PSYCHOPHYSICAL HEALTH AND PHYSICAL CONDITIONING OF WOMEN WHO ACTIVELY EXERCISE

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ABSTRACT

The aim of the research was to determine the possible changes in the parameters that show the psycho-physical health and the level of physical conditioning in female exercisers after three months of training within different kinds of recreational programmes. Thirty women between the ages of 25 and 45, who have been doing various forms of recreational exercises (Pilates, step aerobics and Tae-Bo) for at least a year, participated in the research. The psychophysical health scale and a short mental health questionnaire were used in the research, as well as the tests for the assessment of the level of physical conditioning, the Harvard Step Test and a two-minute step-in-place test. The results showed a positive impact of physical exercise on the psychophysical and mental health and physical conditioning of women who actively exercise. A statistically significant change was found in both motor tests, the Harvard Step Test ($p = .011$) and a Two-Minute Step-in-Place Test ($p = .035$). In the field of psychophysical health, a statistically significantly lower prevalence is noticeable in the overall psychophysical health disorder ($p = .001$), physical health disorder ($p = .001$), fear and anxiety ($p = .002$), depressive reactions ($p = .005$), fatigue ($p = .009$), and the social behaviour disorder ($p = .009$). Regarding mental health, a higher frequency of mental health indicators ($p = .009$) was observed after three months of having been engaged in various recreational forms of physical activities. Therefore, it can be concluded that recreational exercising has a positive effect on the level of psychophysical health and the general physical conditioning of women.

Keywords: recreational exercising, psycho-physical health, female exercisers, aerobic endurance

INTRODUCTION

According to the definition of the World Health Organisation, health is "a state of complete physical, mental and social well-being, not just the absence of disease and disability", which can be further explained as "a resource for everyday life, not the aim of living." "Health is a positive concept that emphasises social and personal resources as well as physical capacities" (WHO). It can also be said that it is "the body's ability to adapt to its threats and weaknesses" (Lancet, 2009). When talking about health, several dimensions are mentioned that make up the overall health of an individual in the sense of one's physical, psychological, social, and emotional health. The join of physical and mental health is very dominant and relevant for assessing one's condition.

A person whose functions in the body take place without disrupting physiological processes is considered to have good physical health, not only because of the absence of disease, but also because of a well-ordered life that is reflected in regular physical activity, a balanced diet, optimal rest, and a sufficient amount of sleep. Establishing and maintaining physical health and good physical

conditioning depends on a healthy lifestyle based on daily, lifelong physical exercising that reduces the risk of disease or delays the onset of many chronic conditions and diseases (Ruegsegger & Booth, 2018). Physical health largely depends on the cardiovascular condition of the body. It is generally accepted that regular physical activity is beneficial for cardiovascular health, as it affects the reduction of cardiovascular mortality, as well as the risk of developing cardiovascular diseases. Physically active people have lower blood pressure, and exercising beneficially affects the heart, as it increases the cardiac output and contributes to a lower resting heart rate (Nystoriak & Bhatnagar, 2018). Physical activity and its sustained and purposeful performance (exercising) promote a wide and diverse set of metabolic and cardiovascular health benefits (Belanger, Rao, & Robbins, 2022). Therefore, it is necessary to work on the development of aerobic endurance as one of the indicators of general physical preparation and the physical conditioning of the organism because endurance training has multiple beneficial effects on cardiovascular health (Idrizović et al., 2021). Aerobic endurance represents the ability to perform some motor activity of low and moderate intensity when the need for the oxygen is met during the performance of that activity, while increasing this ability is done by developing and maintaining the maximum consumption of oxygen as long as possible, as well as by achieving the maximum values of the speed of the respiratory processes (Milenković, 2021).

Physical health is significantly related to the psychological and mental state of each individual. It has been found that exercising, especially in a natural environment, can have more positive effects on mental health, as the research strongly support conclusions about the beneficial effects of acute exercising on general well-being and stress levels (Klaperski et al., 2019). The positive effects of exercising are recognised in mood states, such as anxiety, stress and depression, through physiological, psychological and biochemical mechanisms. It is the reason why it is considered that the mind and body are connected because if a person is of good physical health, then he also acquires psychological health, that is, he reaches the equilibrium of his organism (Chekroud et al., 2018).

Numerous hypotheses have aimed to explain the association between exercising and better mental health. Namely, the cognitive-behavioural hypothesis, the social interaction hypothesis and the distraction hypothesis are psychological ones, while the cardiovascular readiness hypothesis, the amine hypothesis and the endorphin hypothesis are physiological. Cox (2005) believes that understanding the connection between exercising and better mental health can be achieved through an eclectic and multidimensional approach. According to the cognitive-behavioural hypothesis, exercising encourages positive feelings and creates a sense of achievement and self-efficacy, which prevents the negative affect associated with depression, anxiety and other unpleasant moods. The social interaction hypothesis asserts that joint exercising with friends and colleagues provides pleasure, and thus improves mental health. The distraction hypothesis assumes that exercising diverts a person's attention from depression and worries, and thus has a positive effect. The hypothesis of cardiovascular fitness interprets the positive impact of physical activity on mood disorders by the fact that exercising leads to better cardiovascular fitness, and therefore to a better mood. According to the amine hypothesis, physical exercising has a positive effect on mood disorders because exercising increases the amount of neurotransmitters, which have a positive effect on mood. Furthermore, the secretion of amines such as serotonin and dopamine is reduced in depression. The endorphin hypothesis assumes that exercising affects the secretion of endorphins in the brain. Endorphin acts similar to morphine - reduces pain, develops general euphoria, and thus reduces the level of depression, anxiety and moodiness.

Physical activity can reduce and/or prevent the symptoms and consequences of depression and anxiety (Johnson, Mortensen, & Kyvik, 2020). Systematic research reviews and meta-analyses indicate that physical activity should be included in a therapeutic intervention plan for the prevention and reduction of depression and anxiety (Brown et al., 2013).

It has been empirically found that physical activity has a positive effect on the psychological health of adolescents (Ugwueze et al., 2021), young adults (Granero-Jiménez et al., 2022) and middle-aged people (Kang et al., 2020). The positive impact of physical activity on the mental health of children (Zhang et al., 2022), adolescents (Kandola et al., 2022), adults (Kim & Chung, 2021), and the elderly (Seino et al., 2019) has also been confirmed.

Based on the stated theoretical assumptions about psychophysical health and physical conditioning, the aim of this research was to determine the possible changes in the parameters that show the psychophysical health and the level of physical conditioning in female exercisers after three months of training in different types of recreational programmes.

MATERIAL AND METHOD

Participants

Thirty women between the ages of 25 and 45, who have been doing various forms of recreational exercises (Pilates, step aerobics and Tae-Bo) for at least a year, participated in the research. Before the research was carried out, written consent was obtained from all respondents. The research was approved beforehand by the Ethics Committee of the Faculty of Sports, Union University - Nikola Tesla (Decision no. 140/22).

Measuring instruments

A statistical method was used for this research of a longitudinal character. The data were collected, classified and processed, and then tabulated, interpreted and analysed. As part of the measurement techniques, scaling was used to determine attitudes about the level of psychophysical health, as well as testing with diagnostic tests based on which the level of physical conditioning of the female exercisers, specifically aerobic endurance, was assessed.

Questionnaires on psychophysical health

The psychophysical health scale (SPFZ-1) and a short mental health questionnaire (Mental Health Inventory – 5 (MHI-5)) were used in the research:

The psychophysical health scale (SPFZ-1; Majstorović et al., 2019) is intended for self-assessment of the degree of presence of a psychophysical health disorder. The scale has a total of 23 four-point Likert-type items. The dimensions that make up the scale represent:

- a physical health disorder - e.g., "In the last few weeks, have you had stomach or other digestive problems (gastritis, etc.)?",

- fear and anxiety – e.g., "In the last few weeks, have you been tense and nervous?",

- depressive reactions – e.g., "In the last few weeks, have you had the feeling that you are not worth anything as a person?",

- fatigue – e.g., "In the last few weeks, have you had the impression of being tired for no apparent reason?",

- a social behaviour disorder – e.g., "In the last few weeks, have you avoided meeting people?".

The instruction that was given to the respondents was to determine the degree of feeling in the last few weeks on a four-point rating scale (1 - no, I haven't; 2 - yes, but rarely; 3 - yes, often; 4 - yes, daily). Higher scores indicate poorer health, that is, a higher frequency of symptoms pertaining to a disorder of a certain aspect of health. The results show that the reliability of the entire questionnaire is high (α = .941). The reliability of the fear and anxiety dimensions (α = .806), depressive reactions (α = .883), fatigue (α = .838), and the social behaviour disorder (α = .697) is also high, and the reliability of the physical health disorder dimension is satisfactory (α = .405).
Mental Health Inventory (MHI-5; Berwick et al., 1991; Davies et al., 1988; adapted and edited by Slišković, 2020) consists of 5 items that examine the self-assessment of mental health. The respondent indicates the frequency of the mentioned mental symptoms/conditions on a scale from 1 (constantly) to 6 (never) – e.g., "During the past month, how often have you been happy?" Higher scores indicate better mental health. There is high reliability (α = .818).

Aerobic endurance

Two tests (Wood, 2008) of aerobic endurance were used to assess the level of physical conditioning of female exercisers:
- The Harvard Step Test – for 5 minutes, the female exerciser climbs and descends from a 40 cm high platform at a pace of 30 steps per minute (the cycle is repeated every two seconds). After the allotted time, the female exerciser sits on a chair to measure the pulse rate after the first (measuring 30 seconds from 1-1.5 min), the second (2-2.5 min) and the third minute (3-3.5 min) of recovery. The result is determined by multiplying the total duration of work (t = 300 seconds) by 100 and dividing it by twice the value of the total heart rate (n = 1-1.5 + 2-2.5 + 3-3.5 min) in the recovery periods (number of beats for a period of 30 seconds). This test is proven to be reliable and valid for assessing functional abilities (Yuan, Fu, Zhang, Li, & Shan, 2008; Cooney et al., 2013).
- The 2-Minute Step-in-Place Test – the subject stands up straight next to the wall while a mark is placed on the wall at the level corresponding to the midway between the patella (knee cap) and iliac crest (top of the hip bone). The subject then marches in place for two minutes, lifting the knees to the height of the mark on the wall. The test can be successfully used as an indicator of the level of aerobic abilities (Haas, Sweeney, Pierre, Plusch, & Whiteson, 2017).

Exercise programmes

Three recreational programmes were implemented in the afternoon, three times a week for an hour. When planning and executing the programme, a three-part training structure was used: the introductory part (5-10 min), the main part (45 min) and the final part (5-10 min).

Pilates – the entire course of trainings is accompanied by music of a 60 to 80 beats per minute tempo (bpm - beat per minute). The introductory part of the training includes mobility and warm-up exercises (the number of repetitions is 6-10 times). The main part of the training is characterised by exercises intended for strengthening and shaping certain muscle regions (arm muscles, gluteal region, lower extremity muscles, abdominal muscles, and back muscles (the number of repetitions is 10-12 times)). The final part consists of the stretching exercises of large muscle groups, especially those muscles that were engaged in the main part of the training.

Step aerobics – the muscle groups that will be engaged in the main part of the training should be prepared in its introductory part. In order to prepare the body for more intense exercising, simpler coordination and small range of motion exercises with a moderate pace (120-134 bpm) are used. The main part of the training consists of the aerobic part (122-140 bpm) which includes more complex choreographies with basic steps, lifting steps, outbursts, and touch steps, which are afterwards followed by the part of strength exercises on the ground (115-125 bpm). These exercises are intended to increase muscle endurance, repetitive strength and flexibility. In the final part of the training, with the music of a slower tempo (50-90 bpm), the body is calming down by means of stretching exercises of those muscle groups that were most engaged in the main part.

Tae-Bo – the introductory part (100-120 bpm) is meant to warm up and prepare the organism for the stresses to follow by means of simple choreographies composed of the basic steps of walking and running in place and in movement. The main part consists of two parts: the aerobic one (movements, blocks and sequences of movements aimed at the development of the cardiovascular and respiratory system) and shaping exercises (exercises for shaping and strengthening the body) accompanied by the music tempo of 100 to 120 beats per minute. In the course of this part of the training, the load on the cardio-respiratory system is low, and the exercises performed are intended for strengthening the muscles of the arms and shoulder girdle, abdominal wall, back, gluteal region, and legs. In the final part, stretching and relaxation exercises are performed in order to calm down the body (40-60 bpm). Each static stretching exercise is performed in plank for 20 seconds.

Statistical analysis

IBM SPSS Statistics v. 21 was used for data processing. Among the descriptive parameters, the arithmetic mean and standard deviation were used, and in order to register possible changes, the t-test for dependent samples was conducted. The level of significance is $p < .05$.

RESULTS

This chapter shows the changes in aerobic endurance and psychophysical and mental health parameters recorded in female exercisers after three months of training.

Table 1: Changes in aerobic endurance of female exercisers

aerobic endurance	testing	AS	SD	Sig
Harvard Step Test	pre-test	100.43	3.08	.011
	post-test	102.43	2.85	
2-Minute Step-in-Place Test	pre-test	118.67	5.29	.035
	post-test	121.93	6.4	

The results in Table 1 show the determined changes in the aerobic endurance tests that were recorded in female exercisers after three months of training. Statistically significant changes were found in the Harvard Step Test ($p = .011$) and the 2-Minute Step-in-Place Test ($p = .035$), indicating greater aerobic endurance noted in the second test.

Table 2: Changes in the prevalence of parameters pertaining to the female exercisers' psycho-physical health

SPFZ-1	testing	AS	SD	Sig
Physical health disorder	pre-test post-test	5.4 4.13	1.81 1.01	.001
Fear and anxiety	pre-test post-test	7.67 5.77	2.94 1.33	.002
Depressive reactions	pre-test post-test	13.83 10.8	5.41 1.92	.005
Fatigue	pre-test post-test	5.87 4.47	2.6 1.14	.009
Social behaviour disorder	pre-test post-test	8.8 7.23	2.95 1.1	.009
Overall psychophysical health disorder	pre-test post-test	41.57 32.4	13.85 5.22	.001

There are statistically significant changes (Table 2) in the prevalence of the parameters pertaining to the female exercisers' psychophysical health after three months of training. A lower prevalence of the physical health disorder was recorded after three months of training, compared to the first test. Besides, in the second testing, a lower prevalence of fear and anxiety, depressive reactions, fatigue, and the social behaviour disorder, as well as the overall psychophysical health disorder were found after three months of training.

Table 3: Changes in the prevalence of female exercisers' mental health

MHI-5	testing	AS	SD	Sig
Mental health	pre-test post-test	20.43 23.8	4.01 3.35	.001

Table 3 shows the changes found in the mental health of female exercisers that were recorded between two tests in the interval of three months of training. Statistically significant changes in the female exercisers' mental health indicate a higher frequency of mental health indicators after three months of training in the second, compared to the first testing.

DISCUSSION

This research showed the positive impact of physical exercise in terms of various forms of recreational activities on the psychophysical and mental health and physical conditioning of women who actively exercise. After three months of training, the changes in all parameters examined were statistically significant. It was found that in the area of aerobic endurance, as an indicator of the level of physical conditioning, a statistically significant change was recorded in both motor tests, the Harvard Step Test ($p = .011$) and the 2- Minute Step-in-Place Test ($p = .035$). The results of previous research also suggest that the optimal intensity of exercising can have positive effects on cardiovascular health indices in women of a younger age and in good health (Idrizović et al., 2021), when observing different forms of recreational exercising (Milenković & Nikić, 2018; Milenković & Nikić, 2020). Physical exercises result in numerous health benefits and are an important tool when fighting obesity and comorbidities, especially cardiovascular disease. If a person performs physical exercises, on the one hand, the occurrence and development of cardiovascular diseases is prevented, and on the other hand, it is an important therapeutic tool for improving outcomes for patients with cardiovascular diseases (Pinckard, Baskin, & Stanford, 2019). The previous research has so far indisputably shown that regular exercising is beneficial for the cardiovascular system in young, old, healthy, and sick populations. Those are the reasons why physical activity is recommended worldwide for the prevention and treatment of cardiovascular diseases (Moreira, Wohlwend, & Wisløff, 2020). In this regard, Belanger, Rao and Robbins (2022) claim that regular exercising is the most effective way of

strengthening cardiorespiratory fitness, a measure of global cardiovascular, pulmonary and metabolic health and one of the strongest predictors of future health.

As far as psychophysical health is concerned, this research has shown that a statistically significant change is noticeable at the overall level (the overall psychophysical health disorder - p = .001). As for individual indicators, a statistically significantly lower prevalence of the physical health disorder (p = .001), fear and anxiety (p = .002), depressive reactions (p = .005), fatigue, (p = .009), and the social behaviour disorder (p = .009) has been noticed. Regarding mental health, a higher frequency of mental health indicators (p = .001) was observed after three months of being engaged in various recreational forms of physical activities. These results are consistent with numerous studies that have confirmed the positive effects of physical activity on the reduction of depressive and anxiety symptoms. Namely, a meta-analysis (Li et al., 2022), which encompassed 21 studies and included 2594 elderly participants, confirmed the positive effect of physical activity on depressive symptoms. In an additional meta-analysis (Kim, 2022), on the sample of 3,070 middle-aged respondents from numerous studies, it was confirmed that regular physical activity reduces depressive symptoms. North, McCullagh and Tran (1990), in their meta-analysis which unified studies on the connection of physical activity and depression, concluded that acute and regular exercising reduces depression; that exercising is associated with a reduction in the symptoms and state of depression; that exercising alleviates depression in mentally healthy people, but also in people undergoing psychiatric treatment; and that the duration of exercising (in weeks) and the amount of exercising (during the week) were associated with the degree of reduction in depression.

A meta-analysis on samples of elderly respondents (Wu et al., 2022) confirmed the impact of physical activity on reducing anxiety. Petruzzello et al. (1991), through their meta-analysis which examined the final measure of the effect of physical activity on anxiety reduction, came to the conclusions that the exercising time should be longer than twenty minutes to have an effect on anxiety reduction, that acute and regular exercising reduces anxiety and that the exercising programme should last longer than ten weeks to be effective in reducing anxiety.
Masala et al. (2017) agree that regular physical activity improves psychophysical performance and social relationships, as well as, no less important, work performance and ability to work, which reduces sick leave, absenteeism and work injuries. Herbert et al. (2020) found significant improvements in fighting depression, general perceived stress and perceived stress due to uncertainty in their six-week intervention involving aerobic exercising. Therefore, it has been determined that there is a connection between regular physical activity, cardiovascular conditioning, mental health, and well-being.

The results of the previous studies also show that physical inactivity is associated with lower levels of positive mental health, especially physical inactivity in spare time, as well as prolonged sitting (Tamminen et al., 2020), and that there is a very significant connection between physical activity and depression, suggesting a significant mental health benefit from physical activity (Pearce et al., 2022). Finally, it should be said that physical activity is increasingly viewed as an essential component of mental health treatment and that more engagement is needed in terms of promoting physical activity in all environments, both indoors and outdoors (park-based physical activity), in order to improve physical and mental health (Mailey, Besenyi, & Durtschi, 2022).

CONCLUSION

With increasing understanding of the impact of various lifestyle factors, such as sedentary behaviour and the level of physical activity, on physical and mental health, more and more attention is being paid to the fact that regular organised physical activity is necessary for optimal maintenance of the overall psychophysical health status of the organism. In this sense, there are numerous studies that indicate the health benefits of regular physical activity, some of which are mentioned in this study.

Exercising is associated with a reduced risk of all-cause mortality, stroke, cardiovascular disease, and diabetes (Chekroud et al., 2018). It also emphasises the importance of physical activity in relation to the level of mental health in adults because physical inactivity is strongly associated with mental health that is at a low level, which can further pose a risk for mental illness (Tamminen et al., 2020). Therefore, it is constantly suggested that it is important to increase physical activity in the entire population, especially in those who are the least active. Consequently, the results of this research show the importance of exercising and the impact it has on cardiovascular parameters in the form of aerobic endurance tests, as well as the level of psychophysical health. After three months of training in various recreational programmes, female exercisers showed improvement in indicators of aerobic endurance and in the level of psychophysical health. In the modern world, where people are increasingly dependent on new technologies, people's health is neglected, both physically and psychologically. So, this research is another opportunity to point out the importance of this problem.

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PSIHOFIZIČKO ZDRAVLJE I FIZIČKA KONDICIJA ŽENA KOJE AKTIVNO VJEŽBAJU

SAŽETAK

Cilj istraživanja bio je utvrditi moguće promjene u parametrima koji prikazuju psihofizičko zdravlje i nivo fizičke kondicije vježbačica nakon tri mjeseca treniranja u okviru različitih vrsta rekreativnih programa. U istraživanju je učestvovalo 30 žena starosti između 25 i 45 godina koje se bave različitim oblicima rekreativnog vježbanja (Pilates, step aerobik i Tae-Bo) minimum godinu dana. U istraživanju su korištene skala psihofizičkog zdravlja i kratki upitnik mentalnog zdravlja, kao i testovi za procjenu nivoa fizičke kondicije, Harvardski step-test i 2 minuta koračanja u mjestu. Rezultati su pokazali pozitivan uticaj fizičkog vježbanja na psihofizičko i mentalno zdravlje te fizičku kondiciju žena koje aktivno vježbaju. Ustanovljena je statistički značajna promjena u oba motorička testa, Harvardski step-test (p = ,011) i 2 minuta koračanja u mjestu (p = ,035). Na polju psihofizičkog zdravlja, primjetna je statistički značajno manja izraženost kod ukupnog poremećaja psihofizičkog zdravlja (p = ,001), poremećaja fizičkog zdravlja (p = ,001), straha i anksioznosti (p = ,002), depresivnih reakcija (p = ,005), umora (p = ,009) i poremećaja socijalnog ponašanja (p = ,009). U pogledu mentalnog zdravlja primjećuje se veća učestalost indikatora mentalnog zdravlja (p = ,009) koja je uslijedila nakon tri meseca bavljenja različitim rekreativnim oblicima fizičkih aktivnosti. Može se zaključiti da rekreativno vježbanje pozitivno utiče na nivo psihofizičkog zdravlja i stanje opšte fizičke kondicije žena.

Ključne riječi: rekreativno vježbanje, psihofizičko zdravlje, vježbačice, aerobna izdržljivost

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WHO TO ENGAGE IN PROMOTION? THE POSITION OF ATHLETES IN CELEBRITY ENDORSEMENT COMMUNICATION STRATEGIES

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ABSTRACT

The challenge that marketers face today is how to gain attention with the content they create, and one of the best and most common ways to stand out from other competitors is to engage celebrities for promotional purposes. Celebrities are defined as individuals, such as actors, singers and athletes, who are recognisable to the public by their achievements in sectors related to the products and services sector they promote. This research examines the reasons for the increasing engagement of athletes in promotional activities. It provides answers to the shortcomings as well as gaining insight into the methods used by companies in making decisions about choosing a famous athlete, and what are their most important characteristics. In this research, two basic methods for data collection and analysis were conducted - the method of theoretical analysis and the survey method. Based on the conducted research and the obtained results, this article shows that companies in Serbia follow the trends related to celebrities and promotional activities. All companies stated that they used or are using celebrities for promotional purposes.

Keywords: sponsorship, promotion, athletes, sport marketing

INTRODUCTION

In order to take advantage of a brand's promotional efforts, sponsorship is the purchase of the right to be associated with a certain event, product or individual (Hardy, Mullin, & Sutton, 2007). BYB Marketing (2020) points out that the intention of cooperation between companies and celebrities is much more subtle than direct advertising, and therefore consumers do not have a defence mechanism for this type of promotional activity. The engagement of celebrities in promotion of the brand, products or services attracts a lot of public attention. Raising brand awareness is one of the most important reasons for investing in sponsorships (Zipporah & Mberia, 2014). Through a sponsorship relationship with celebrities, brands can send their brand message through them and get closer to their target group. Guided by that, companies annually allocate millions of euros for hiring celebrities in their promotional activities (Zipporah & Mberia, 2014). As Ognjanov (2013) points out, every investment in sponsorship implies at least twice as much investment in the accompanying activities of advertising the

sponsored activity itself. Cobbs and Groza (2020) state that collaboration with celebrities is a long-term relationship, but more digital short-term activities are being introduced into sponsorship plans and strategies. Zlingit (2021) pointed out that it will be no wonder if we see only digital promotional partnerships. In recent years, more and more celebrities are engaging in digital channels to represent brands - actors, athletes, musicians, experts in certain fields, etc.

Ayyala et al. (2019) state that both companies and individuals hired by these companies benefit from sponsorships and promotional collaboration. Kunkel et al. (2019) indicate that the use of celebrities in promotional activities is a useful and effective marketing strategy for companies attempting to increase brand awareness and sales. Friedman (2021) notes that companies must make a good choice of the celebrity they will engage in the promotional campaign. Agraval and Kamakura (1995) claim that the success of engaging influential people in the promotion of products or services is reflected in the fact that people want to change their lives or lifestyles and identify with celebrities. In order to achieve the goals of the campaign, companies must choose a famous person with ideal characteristics that will suit their brand. BBS Communications Group (2019) points out that a good decision will lead to less risk of making a mistake. In today's digital age, it is easier than ever to destroy a brand's reputation.

A 2018 study conducted by the Association of National Advertisers (2018) showed that 75% of companies hired celebrities in their marketing campaigns and planned to focus their budget on these activities in 2021. Celebrities and influential people that companies choose in their campaigns differ in personality, demographics and content they publish. Companies struggle every day to choose the right person who will match the characteristics of their product and service (Gross, 2020). Before identifying ideal celebrities for their campaign, companies should pay attention to the following characteristics - relevance for the product, engagement, reach, frequency, and authenticity (Vodak, Cakanova, Pekar, & Novysedlak, 2019).

Well-known people will enable all promotional activities to reach many people and make the brand more visible. Also, their credibility will strengthen the attitude towards the brand (Bakker, 2018). Fitri (2018) pointed out that the characteristics of influential people, such as credibility, attractiveness and familiarity, have a positive influence on brand image. In their study, Chan et al. (2021) investigated the effect characteristics of celebrities and influential people have on the brand image of Vivo. The results show that trustworthiness, expertise, physical appearance, respect, and similarity of the celebrity have a beneficial and notable impact on brand image.

According to StarNgage (2021) a platform for marketing influential people, in Serbia, singers, actors, people who offer informative and educational content, and YouTubers are at the top of the list of the most influential people. The most influential people and celebrities in Serbia can be found on Twitter and Instagram (Bogićević, 2020). A Forbes article (2020) indicated that, increasingly, companies engage celebrities in their promotional activities, especially athletes. This is one of the ways to humanise the brand and establish a more loyal relationship with customers. Based on the Statista report (2022) relating to Sports sponsorship revenue worldwide, the data show that the size of the sports sponsorship market in 2021 was 64.8 billion U.S. dollars, providing a forecast for 2030. In the measured period, the market size is expected to grow by 7.5 percent to 112.2 billion U.S. dollars. Based on the research conducted by Zak and Hasprova (2020), they conclude that athletes are the most trusted people for up to 44.5% of respondents. Voráček and Bernardová (2021) conclude that approximately one-half of the respondents are more likely to be influenced to purchase a product promoted by an athlete.

As mentioned in the SportsPro 50 Most Marketable platform (2021), tennis and soccer players are the most numerous among the top 15 most influential athletes. Based on an analysis of the Mediakix Agency (2020), the use of celebrities and their characters on Instagram alone exceeds the amount of one billion dollars. The most followed athlete on Instagram is Cristiano Ronaldo, with 496 million followers (Cristiano Ronaldo [@cristiano], 2022). Transfer to Paris Saint-Germain affected the growth of Leo Messi's number of followers, which has increased by 40 million. He currently has 372 million followers on this platform (Leo Messi [@leomessi], 2022).
The main purpose of this paper is to examine the reasons for the engagement of celebrities and influential people in promotional campaigns. It provides answers to the shortcomings as well as gaining insight into the methods that companies use in making decisions about the selection of people to sponsor. The main goal of this research is to examine which people are most engaged in the activities of promoting a company, product or service.

METHODS

In accordance with the set goal of this paper, the conducted research refers to the reasons for the increasing engagement of athletes in promotional activities. To find answers to the questions important for this research, an anonymous electronic survey was created on the Survey Planet page.

For research purposes, a survey was created with scale questions. This instrument was specially created for the purpose of this empirical research. The survey consists of questions for determining whether companies conduct research on endorsers before engaging them, what are the most important characteristics of the endorser for the company, the presence of endorsers on social media, and which influencers are most important for building the company's brand.

The survey consisted of 19 questions. The first 4 questions refer to whether the companies engaged celebrities in the promotion of the brand/product/service, how often they did it, whether they did it independently or with the help of marketing agencies, and whether before choosing the celebrities they did any research and segmentation of target groups. The next 4 questions refer to the characteristics of celebrities that are important to companies when selecting them for promotional campaigns. The following 4 questions refer to the choice of persons when promoting products or services as well as when building the brand image. After that, 2 questions refer to whether companies use one or more persons for building a brand image as well as promoting products or services. The last 5 questions in the survey provide answers to whether the company evaluates the performance of hiring celebrities, whether they would decide to hire the same celebrity again, and what is the size of the company and the branch to which they belong.

The types of questions in the survey were rating scale questions and single-answer questions (for some questions there was an option to give only one answer). After completing the survey online, the results were summarised, and the data obtained was processed. In rating scale questions, the question displays a scale of answer options ranging from 1 to 4, 1 to 6, and 1 to 7. In these ranking scale questions, the number of elements and options that can be marked determines the ranking number. In questions where 4 characteristics are offered, 4 points are available that can be allocated to them. It is the same with questions that have 6 and 7 features offered. In the questions related to the ranking by the importance of the offered answers, the scaling of the most significant answer was marked with 1, and the least significant with the highest offered number. By adding all the entered points, we got an insight into the most important characteristics of people that companies will use in their marketing activities. After adding up the scores, we used average values for the final ranking and presentation of the results.
In the first question, companies gave 1 to 7 points for each option offered. They had to give a certain rating for each option. By adding all the entered points, we got an insight into the most important characteristics of people that companies will use in their marketing activities. Those characteristics that have the lowest score after addition are the most important characteristics because grade 1 was given for the most important of the offered. In the second question, the scaling of the most significant answer was marked with 1, and the least significant with the number 7. Additionally, in the fourth and fifth question, the scaling of the most significant answer was marked with 1, and the least significant with the number 6.

A survey was sent to 36 small, medium and large companies. Directors of the mentioned companies participated in the research, and the response rate was 86% (31 out of a total of 36 companies). Directors were directly informed about the electronic survey, which was posted on the internet. As part of the survey, the directors were informed about the goals and objectives of the survey, that the data will be used exclusively anonymously and that, at any time, they can withdraw their answers from the survey. Out of 31 companies, 71% belong to the category of large companies, 16.1% to medium, and 12.9% to small companies. In accordance with the Law on Accounting and Auditing, according to the size of companies in Serbia, they are classified into small, medium and large legal entities, depending on the average number of employees, annual income and property value determined on the date of drawing up the financial statements in the business year (Avlijaš, 2008).

Numerical data were processed by descriptive analysis with the help of SPSS 21. From descriptive statistics, frequencies of responses and percentage shares of individual responses were used.

RESULTS AND DISCUSSION

The companies that participated in the survey come from different sectors, and about 32% belong to the food and beverage, followed by the banking and insurance companies. In addition to the above, companies from the telecommunication, fashion, cosmetic, trade, transport, and medical sector also participated.

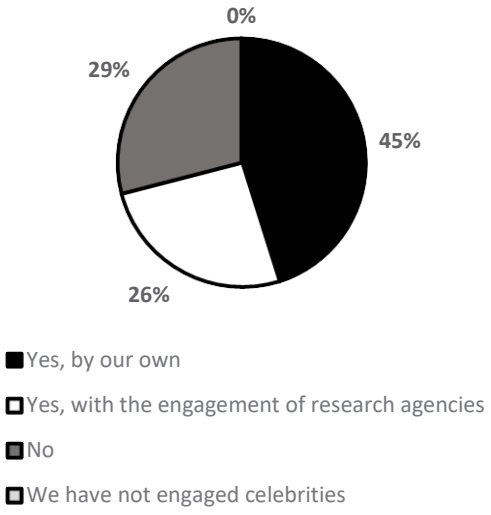
All the company directors answered that they hired a celebrity to promote their products or services. Based on that result, we can conclude that companies operating in Serbia do not lag behind in hiring celebrities. Almost 80% of companies engage celebrities as promoters often or occasionally, while only about 20% of them said they rarely do so.

As many as 60% of the surveyed companies use the recommendations of PR and marketing companies for choosing the right celebrity as a representative of the image of their company, while 40% do it independently. Answering to the question "if you are a representative office of an international company, do you have to have

the consent of the headquarters for the engagement of influencers on social media", 32.3% of companies stated that the question is not applicable to them, and 67.7% of surveyed companies are part of an international network. If we add the demographic data of companies, 71% of companies are classified in the category of large companies (over 250 employees), 16.1% in the category of medium (50-250 employees), and only 12.9% in the category of small (up to 50 employees) companies. It is assumed that large international companies are mostly those that use the services of the agency when choosing an "endorser" even though this is not the case for all of them (at least not for 7.7% of them).

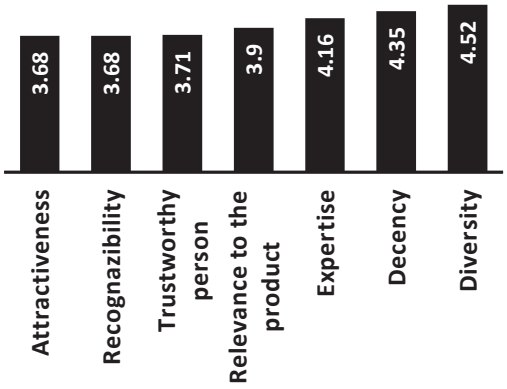
Several large and medium-sized companies make their decision on choosing a famous or well-known person. In 43% of the cases, international companies have autonomy in making decisions on hiring a celebrity in Serbia, and 57% of them must have the approval of the headquarters. In 71% of the cases, the decision on selection is preceded by the research of target groups, out of which 45.2% of companies do it independently, and 25.8% with the help of marketing agencies. Almost a third of the companies do not conduct any research. (Figure 1)

Figure 1: Do companies conduct research on target groups before selecting an endorser?



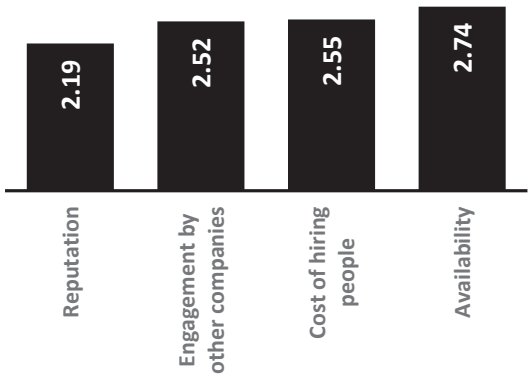
The surveyed companies in Serbia stated that the most important characteristic is the attractiveness of hired people for a promotional campaign. Attractiveness, credibility and familiarity of influential people can positively impact a company's image according to Fitri (2018). Then comes the recognition that it is a person who is trusted. The least important characteristic for companies is diversity, and before that, also less important characteristics are the decency and expertise of that person. Many companies believe that in addition to being attractive, it is important for an influencer to be a recognisable and trustworthy person. If followers do not trust that person, they will not be able to sell the product and communicate the brand message. (Figure 2).

Figure 2: Ranking of the most important characteristics of the endorser



It is interesting to compare these answers with the answers to the next, similar but extended question. The most important is the reputation of the engaged person, which is somewhat in contradiction with the result from the previous question. Decency is almost in last place. Interestingly, the difference between the reputation and the cost of hiring a person is not very big. This data can provide a potential answer to the increasingly common situation of influential people promoting many products. Participation in many different campaigns can lead to reduced quality and results of promotional activities. (Figure 3)

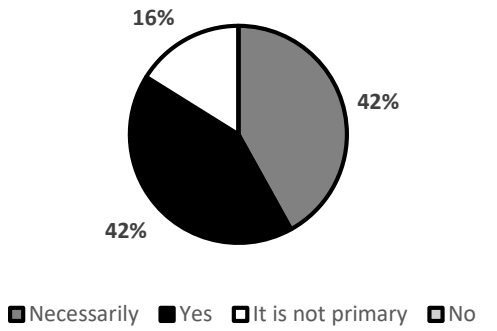
Figure 3: Ranking of the most important characteristics of the endorser



That great popularity does not have to bring only benefits was confirmed by as many as 78% of companies in Serbia. They believe that a person can be a bad choice of a promotional person due to his great popularity. All companies agreed on the importance of the presence on social media platforms of persons participating in our promotional campaigns. Social media allows individuals to connect with friends, peers, or business associates. With constant

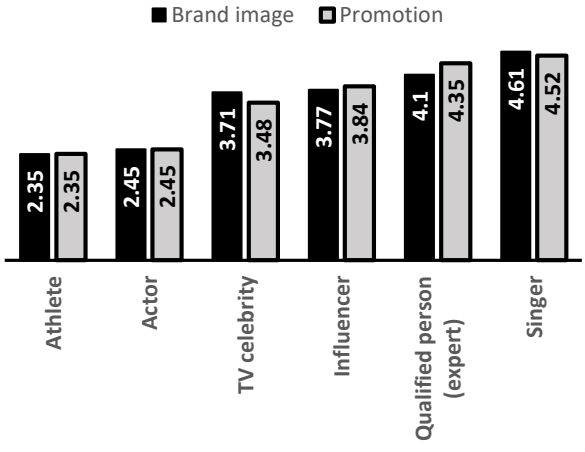
activity on social media, influential people create communities. These people follow their work and everything they do. Celebrities through interaction with followers can create deeper relationships with them and gain their loyalty. (Figure 4)

Figure 4: The presence of "endorsers" on social media



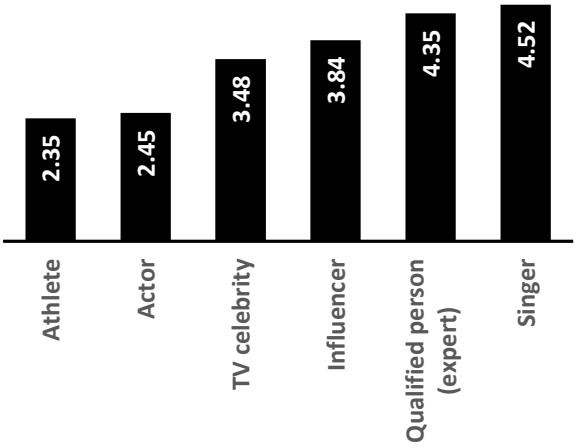
Companies in the survey were given options for different answers for image-oriented engagements, and for those aimed at promoting services or products. In both options, they had the same choice - athletes, actors, TV personalities, influencers, professionals, and singers. Since all the mentioned people can be influential people, it is necessary to emphasise that influencers in this context include so-called native influencers. Native influencers are known only for their presence on social media, mostly Instagram and Twitter. This information agrees with the claim of Bogićević (2020) who stated that the most influential people and celebrities in Serbia can be found on Twitter and Instagram. The most attractive promotional figures in Serbia are athletes, as individuals, not sports teams. As mentioned in the Forbes article (2020) companies engage celebrities increasingly in their promotional activities, especially athletes. Immediately behind them are actors, while convincingly the last choice of companies in Serbia are singers. (Figure 5)

Figure 5: Selection for the brand image campaign; 1 - first choice, 6 - last choice



The order of attractiveness of the profession is the same as in the promotion of the company's image - in the first place are athletes, and in the last singers. As Voráček and Bernardová (2021) pointed out, approximately half of the respondents in their study were more likely to be influenced to buy a product promoted by an athlete. The results of this answer coincide with the previous one. The difference in the attractiveness of the influential person's occupation between the first and the last choice is very noticeable. These are interesting data because according to the mentioned research, the largest number of followers on social media in Serbia are singers. This confirms the conclusion based on the above research that the number of followers on social media does not have a direct impact on the decision to hire for promotional campaigns as well as the quality of service provided by that person. (Figure 6)

Figure 6: Selection of professions in promotional campaigns; 1 - first choice, 6 - last choice



When companies in Serbia hire celebrities for promotional purposes, they usually decide to hire one person. And as expected, a slightly larger number of "endorsers" are hired when advertising products or services.

Almost all companies that participated in the survey, more precisely, 87% of them evaluate the performance achieved by hiring celebrities, and 84% of companies claim that they would decide to hire the same person for promotion.

CONCLUSION

Companies struggle every day to choose the right person who will match the characteristics of their product and service. Companies and marketing managers should carefully choose the type of celebrities best suited for a particular campaign. It is important to recognise the main characteristics by which companies choose

influential people and celebrities in their campaigns. Athletes are widely used in promotional activities and based on the use of celebrities in sharing promotional messages, brands are easier to remember. Athletes are increasingly being used as influential people in promotional campaigns, and budgets for influence marketing are increasing year by year. The main purpose of the research was to examine the reasons for the increasing engagement of athletes in promotional activities. An anonymous electronic survey was conducted to gather the answers to the main questions for this research. In Serbia, companies find that the most important characteristics of a hired person are his attractiveness and recognisability, thus confirming the first hypothesis of this paper. In addition to these factors, the companies stated that their reputation, trustworthiness, and expertise are also important to this. This result is quite consistent with the previous research. Also, what all surveyed companies in Serbia pay attention to when choosing celebrities for promotional purposes, is the presence and engagement on the social networks of hired celebrities.

This study can offer brand communication managers important information on how to communicate and design sponsorship disclosures to reach-desired responses from consumers. The research will enable marketers to compare promotional activities in Serbia with world trends, as well as to get an insight into which are the most attractive professions in Serbia that celebrities are engaged in. The research also contributes by providing useful information on what are the most important attributes when companies make decisions about hiring a famous person to communicate their message.

Company directors in Serbia, which participated in the survey, state that the most attractive profession for engaging in the promotion is a sport, respectively athletes, as individuals. Athletes are the most desirable people when it comes to hiring celebrities for promotional purposes. As many as 87% of companies evaluate the performance achieved by hiring celebrities, and 84% of companies claim that they would decide to hire the same person for promotions. The general recommendation for further research on this topic is to increase the number of respondents and to increase the data related to the whole country.

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KOGA ANGAŽOVATI U PROMOCIJI? POLOŽAJ SPORTISTA U KOMUNIKACIJSKIM STRATEGIJAMA POZNATIH LIČNOSTI

SAŽETAK

Izazov sa kojim se marketari u današnje vrijeme suočavaju je kako privući pažnju potrošača sadržajem koji kreiraju. Jedan od najboljih i najčešćih načina za izdvajanje od ostalih konkurenata je angažovanje poznatih ličnosti u promotivnim aktivnostima.

Poznate ličnosti se definišu kao pojedinci, kao što su glumci, pjevači i sportisti, koji su prepoznatljivi javnosti po svojim dostignućima u sektorima koji su povezani sa sektorom proizvoda i usluga koje promovišu. Ovo istraživanje ispituje razloge sve većeg angažovanja sportista u promotivnim aktivnostima. Istraživanje pruža odgovore na nedostatke kao i sticanje uvida u metode koje kompanije koriste u donošenju odluka o izboru poznatog sportiste i koje su njegove najvažnije osobine. U ovom istraživanju provedene su dvije osnovne metode prikupljanja i analize podataka - metoda teorijske analize i metoda anketiranja. Na osnovu provedenog istraživanja i dobijenih rezultata, ovaj rad ukazuje na to da kompanije u Srbiji prate trendove vezane za angažovanje poznatih ličnosti u promotivnim aktivnostima. Sve kompanije su izjavile da su koristile ili koriste poznate ličnosti u promotivne svrhe.

Ključne riječi: sponzorstvo, promocija, sportisti, sportski marketing

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