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DEAR READER,

This issue brings new scientific papers covering many areas of sport science. The papers are written by researchers from 15 countries, bringing new knowledge and values promoted through the results of their research. A multitude of researchers continue to submit their papers for publishing in our journal, and we are very grateful, since they have recognised its quality and effort to promote new scientific and professional achievements whose results ultimately contribute to the given area of sport science.

The Editorial Board was responsible and professional in their approach to the selection of papers for the new issue of Sport Science. In doing so, the quality of the work conducted by the authors represented a priority and a requirement for publishing their papers. We would like to thank them for their effort to select the papers which promote scientific thought and contribute to new findings in sport through their results.

We are glad that our journal continues to be the setting for the development of scientific thought and creation of new sports systems despite the effects of the COVID-19 pandemic, which has imposed different forms of sports functioning as a whole and indirectly affected the creation of new values.

Thus, our journal remains a platform for presenting new results which will be applied in practice. Promoting the results and achievements in the area of sport science represents an obligation for our journal to maintain trust and the quality that will satisfy the needs and expectations of our devoted readers.

That is why, we invite you, readers, to become a part of our team and participate in our work so that, together, we could contribute to science and changes in the world of sports.

Nihad Selimović, MD, MSc
Editor-in-Chief

DRAGI ČITATELJU,

Ovaj broj donosi nove naučne radove koji pokrivaju mnoge oblasti nauke o sportu. Riječ je o radovima istraživača koji dolaze iz 15 zemalja te donose nova saznanja i vrijednosti promovisane kroz rezultate njihovog istraživanja. I dalje imamo veliki broj istraživača koji dostavljaju svoje radove za objavu u našem časopisu te smo im zahvalni jer su prepoznali njegov kvalitet i nastojanje da promoviše nova naučna i stručna dostignuća čiji rezultati u konačnici doprinose datoj oblasti nauke o sportu.

Recenzentski odbor je odgovorno i profesionalno pristupio odabiru radova za novi broj časopisa Sport Science. Pri tome je kvalitet autorskog rada predstavljao prioritet i uslov za njegovu objavu. Zahvaljujemo im se na naporima da odaberu radove koji promovišu naučnu misao i rezultatima doprinose novim saznanjima u sportu.

Sretni smo što naš časopis i dalje ostaje mjesto za unaprjeđenje naučne misli i stvaranje novih sportskih sistema uprkos posljedicama pandemije COVID-19 koja je nametnula drugačije oblike funkcionisanja sporta u cjelini te indirektno uticala na stvaranje novih vrijednosti.

Time naš časopis ostaje platforma za predstavljanje novih rezultata koji će svoju primjenu naći u praksi. Promocija tih rezultata i dostignuća na području nauke o sportu predstavlja obavezu našeg časopisa da održi povjerenje i zadrži kvalitet koji će zadovoljiti potrebe i očekivanja naših vjernih čitatelja.

Upravo zato pozivamo Vas, čitatelje, da budete dio našeg tima i učestvujete u našem radu kako bismo zajedno doprinijeli nauci i promjenama u svijetu sporta.

Mr. sci. dr. Nihad Selimović
Glavni urednik

DETERMINING NORMATIVE DATA FOR THE STANDING POWER THROW (SPT) IN DIVISION II COLLEGE ATHLETES

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ABSTRACT

The standing power throw (SPT) is an assessment that is used to evaluate dynamic strength. The SPT has recently become popular due to its ability to estimate total body explosive power and its ability to be used as a measuring instrument and training device for athletes of different size and athletic ability. However, the literature review demonstrates a lack of normative data to interpret the normal data distribution of the SPT for athletes. The purpose of this research was to evaluate SPT results to develop gender-based category norms for college athletes. 199 total college athletes participated in the study with 82.9% of the participants being male (n = 165) and 10.8% female (n = 35). T-test results revealed that there is a statistically significant difference between male and female SPT distance (p > .001). Percentiles and categorical rankings for gender were reported, where the weighted average method was used to determine the percentile break points. These norms could be useful for coaches and fitness professionals to effectively and easily assess dynamic strength.

Keywords: backward overhead medicine ball throw, dynamic strength, normative data

INTRODUCTION

Strength training is essential to have a successful athletic performance in all sports and recreational activities (Granacher et al., 2016). Strength training helps improve stamina, speed, and flexibility by increasing muscle mass (Lockie et al., 2019). In addition, strength training has been linked to reducing risk of injuries while performing athletically (Lauersen, Andersen, & Andersen, 2018). A medicine ball is an effective tool for full body training, and assessment in strength is due to its ability to complete explosive movements (Stockbrugger & Haennel, 2001). The potential for high performance in many sports can be assessed by quantifying whole-body explosiveness. Dynamic strength, also known as functional strength, has been growing in popularity as it focuses on large body movements where muscle groups mimic activities of daily life (Rempfer, 2021). In real-world applications, one can have great overall strength, but lack dynamic strength, which does not help in real-world application such as throwing and picking heavy objects up quickly. Assessment and evaluation techniques have evolved to include comprehensive monitoring programmes consisting of both general and dynamic testing (Zemková & Hamar, 2018) as a result of development in scientific research, equipment availability, and testing environmental and overall performance testing practices (NSCA, 2017).

The overhead medicine ball throw, backward overhead medicine ball (BOMB) throw, or standing power throw (SPT), is an assessment that is used to evaluate dynamic strength. The SPT has recently become popular due to its ability to estimate total body explosive power (Mayhew et al., 2005) and its ability to be used as a measuring instrument and training device for athletes of different size and athletic ability (Dockery et al., 2020). Power tests are designed and implemented to quantify athletic performance ability (Manske & Reiman, 2013). However, there is no existing normative data that dictates what a thrown SPT distance means.

PROBLEM AND AIM

Currently, with regards to the SPT, the literature review demonstrates a lack of normative data to interpret the normal data distribution of the SPT for athletic populations (Bigelman et al., 2019). Performance data needs to be understood through the use of normative data. Normative data is essential in order for performance results to be comparable amongst a wider set of a population in the future. This study provides a beginning for criterion-referencing on SPT performance. The purpose of this research was to evaluate SPT results to develop gender-based category norms for college athletes. This study provides a beginning for criterion-referencing for which SPT performance would be using categorical ranking (excellent, good, average, fair, poor) in male and female athletes.

METHODS

A cross-sectional research design was used, with data collected by a National Strength and Conditioning Association (NSCA) Certified Strength and Conditioning Specialist (CSCS) following proper human protection protocol. All testing and training occurred in the same facility and utilised the same equipment for testing. In an effort to obtain a proper subject sample as heterogeneous as the population, all college-aged athletes (18-25) participants were included in the study.

Instrument

Stockbrugger and Haennel (2003) proposed the SPT as a measure of total body explosive power. When comparing SPT with power predicted to standard power assessment, it reported a high correlation ($r = 0.97$) between genders and in trained ($r = 0.82$) and non-trained individuals ($r = 0.92$) (26). The SPT is also significantly correlated ($p < 0.01$) with the two Olympic lifts, snatch ($r = 0.85$) and clean and jerk ($r = 0.90$) (19).

The greater use of the arms in the SPT means that the actual power generated during the SPT is considerably higher than that registered during the average vertical jump, and thus better represents functional movement needs. The SPT motion does not produce a high enough association among other forms of power tests to make predictive outcomes from other assessments (Terzis et al., 2003). This makes the SPT a unique assessment within itself for assessing total body dynamic power production. While this test has been informally used for years prior to evaluate physical performance, there has been little research on what the outcome means in an athletic testing scenario.

The complexity of the total body motion of the SPT and power differ for athletes with different skill sets and performance demands (Stockbrugger & Haennel, 2003). However, the SPT lacks differences among loads of 2.7-5.5 kg. This indicates that the SPT can be used to compare kinetic characteristics for training or measurement among athletes to obtain reference data for programming or evaluation (Beckham et al., 2020). Due to its nature of consistency among different weight, it is recommended that medicine ball throws, such as the SPT, are incorporated into testing of athletes.

Participants

To better comprehend the distance the medicine ball is thrown, the researchers assessed male and female athlete students, aged 18-25, in a small college located in south-eastern United States. Athletes were subdivided by their gender and sport. Collecting normative data is essential to accurately comprehend the data for this study. Any athlete who wished to be a subject for this study and was physically able to, regardless of their current fitness level, was eligible to participate. Subjects eligible for this study were not required to be in-season, exercise on a daily basis, eat healthy, or follow any intense regimens. Participation for this research was recruited voluntarily and was conducted at beach volleyball courts.

Testing Procedure

During the SPT test, subjects was instructed to begin by bending at the knees to grab the ten-pound medicine ball off of the ground. The participant faced away from the start line, grasped the medicine ball (10 pounds) with both hands at hip level and stood with both heels at (but not on or over) the start line. They were instructed to grasp the ball firmly and as far around the sides of the ball as possible, squat down, and then, using a fast and powerful motion, throw the medicine ball behind themselves using an overhead throw (Figure 1).

Participants were allowed several preparatory warm-up movements such as flexing at the trunk, knees, and hips while lowering the ball between their legs. When they were ready, the participants executed their first throw attempt. Distance was recorded in metres at the centre of the landing point of the medicine ball in the sand using a 30-metre tape measure. Participants had two attempts on the SPT, where the score for their best attempt was recorded. An attempt did not count if a participant stepped on or beyond the start line or fell to the ground (pre- or post-throw), and it was determined a fault.

If a participant faulted on the first record throw, they received a raw score of 0.0 metres. If a participant faulted on the second record throw, they received a raw score of 0.0 metres. This participant was allowed one additional attempt to score on the SPT. If the participant faulted on all three record throws, they received a raw score of 0.0 metres for the SPT. If a participant had a valid score on either record, the first or the second throw, they were not allowed a third attempt.

Statistical Analysis

The mean and standard deviation for each test data was calculated according to the players' gender using an independent samples t-test to determine significant means and significant differences according to gender of the groups using IBMS SPSS package. To generate standards, the 5th, 10th, 20th, 30th, 40th, 50th, 60th, 70th, 80th, 90th, and 95th percentiles were reported, where the weighted average method was used to determine the percentile break points (Hoffman, 2006).

Percentile rankings as defined by Roetert et al. (1995) "as a value in the distribution below which a given percentage of the scores is found" by using a 5° scale were defined for the following categories: Excellent = highest 5% or above the 95th percentile, Good = next highest 15% or between the 80th and 95th percentiles, Regular = middle 60% or between the 20th and 80th percentiles, Poor = next lowest 15% or between the 5th and 20th percentiles, and Very poor = lowest 5% or below the 5th percentile.

RESULTS

The purpose of this research was to evaluate SPT results to develop gender-based category norms for college athletes. 199 total college athletes participated in the study with 82.9% of the participants being male (n = 165) and 10.8% female (n = 35). T-test results revealed that there is a statistically significant difference between male and female SPT distance ($p > .001$) (Table 1).

Table 1: Participant Information

Gender	N	Mean	SD	Sig
All Participants	199	11.53	2.88	0.001
Male	165	12.55	1.89	
Female	35	6.61	1.12	

To generate standards for each gender, the 5th, 10th, 20th, 30th, 40th, 50th, 60th, 70th, 80th, and 90th percentiles were calculated using the weighted average method (Cleophas & Zwinderman, 2014) to determine the percentile break points. Percentiles based off of male and female participants can be found in Table 2 and Table 3, respectively.

Table 2. SPT Percentile Rankings for Male Athletes

Percentile	Distance (m)
90%	15.16
80%	14.33
70%	13.51
60%	13.03
50%	12.47
40%	11.96
30%	11.53
20%	10.95
10%	10.31
Mean	12.5545
Std. Deviation	1.89430
Std. Error Mean	0.14747

Table 3. SPT Percentile Rankings for Female Athletes

Percentile	Distance (m)
90%	7.96
80%	7.31
70%	7.03
60%	6.72
50%	6.31
40%	6.07
30%	5.84
20%	5.15
10%	4.69
Mean	6.6080
Std. Deviation	1.12378
Std. Error Mean	0.18995

To further enhance the utility of SPT percentile rankings, categorical rankings were determined for both male (Table 3) and female (Table 4) athletes. The methodology for determining the normative data performance rankings was adopted from prior research (Roetert et al., 1995) and is as follows: Excellent = Highest 5%, Good = next highest 15%, Regular = middle 60%, Poor = next lowest 15%, Very Poor = next lowest 5%. This method of performance ranking is a common practice with a variety of other fitness measures (Hoffman, 2006).

Table 4. SPT Categorical Ranking for Male Athletes

Ranking	Distance (m)
Excellent	≥ 15.73
Good	13.91 - 15.72
Average	10.95 – 13.90
Fair	9.39 - 10.94
Poor	≤ 9.38

Table 5. SPT Categorical Ranking for Female Athletes

Ranking	Distance (m)
Excellent	≥ 8.36
Good	7.30 – 8.35
Average	5.16 – 7.29
Fair	4.04 – 5.15
Poor	≤ 4.03

DISCUSSION

This study aimed to develop normative data for the standing power throw (SPT) for healthy college-age athletes. Our data is based on a sample of 199 subjects, separated into gender-specific percentile ranks. The data was separated into meaningful scoring categories for ease of interpretation and application for coaches. These results are important because they provide the first published SPT normative values and performance rankings for healthy college-age males and females. The normative data and categorical scoring from the present study offers a quick reference guide for practitioners for an easier way to assess and understand standards for practitioners. The performance ratings provide quick feedback on strength and power levels, which can help in establishing training goals, aid in modifying current training programmes, and provide objective data for tracking progress.

Testing a large group's SPT performance can be used to classify a person's strength level prior to their entry to training and also their current fitness level while engaged in highly physical professions. Testing individuals to meet a criterion (excellent, good, average, fair, poor) for a job can provide an understanding of what the individual is physically capable. The findings in gender differences in this study, and a need for creating gender-based rankings, are supported by the findings in other power-based assessments such as the side medicine-ball throw (Ikeda et al., 2007), deadlift (Jones et al., 2016), and within the SPT itself (Beckham et al., 2020

The SPT may also be used when a specific 10 lb medicine ball is available. It has been shown that an SPT may be complete with 6 lb, 10 lb, and 12 lb medicine ball with no significant differences ($p > 0.05$) in peak power, peak force, peak velocity, force at the moment of peak power, or velocity at the moment of peak power using different weighted medicine balls (Beckham et al., 2020). The lack of differences among these medicine ball weights indicates that there is some flexibly within the assessment itself, which makes it a more versatile field assessment for practitioners to use as they can use the size they have on hand without jeopardising the results of the assessment.

The results of this study are able to show normative data for the SPT; however, it is limited for a variety of reasons. The reasons for limitations are the limited age range of using only college-aged student athletes, small sample size, and uneven gender distribution. In order to further discern normative data, more participants of a variety of ages and genders would have increased the number substantially. In addition, the population was uneven in terms of gender distribution and would benefit from a greater proportion of female participants.

CONCLUSION

The application of using the SPT has been shown to be a convenient, safe, and effective method for assessing dynamic strength (Stockbrugger & Haennel, 2001). Evaluation of dynamic strength is common practice for all types of athletic coaches. This is due to its ability to predict key athletic indicators such as strength and power. Having normative data available for the SPT gives coaches a field test that is quick to use, can be done in both outdoor and indoor settings, while providing information on dynamic strength in less than a minute per athlete. The use of normative data for evaluation is only useful if it matches the sample of reference. The specific data provided in the present study will be useful for the assessment of Division II college athletes as a whole, not sport specific. The study provides users two ways to assess dynamic strength, percentile rankings or categorical ratings, to establish a baseline for their athletes. This kind of profiling can be useful for grading, ranking, and programming for athletes.

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UTVRĐIVANJE NORMATIVNIH PODATAKA ZA BACANJE MEDICINKE PREKO GLAVE UNAZAD (SPT) KOD UNIVERZITETSKIH SPORTISTA DIVIZIJE II

Bacanje medicinke preko glave unazad (SPT) je procjena koja se koristi za evaluaciju dinamičke snage. Bacanje medicinke preko glave unazad je nedavno postalo popularno zbog sposobnosti procjene ukupne eksplozivne snage tijela i mogućnosti korištenja u vidu mjernog instrumenta i trenažnog sredstva za sportiste različite tjelesne građe i atletske sposobnosti. Međutim, pregled literature pokazuje nedostatak normativnih podataka za interpretaciju normalne distribucije podataka SPT-a kod sportista. Svrha ovog istraživanja je bila procijeniti rezultate SPT-a za razvoj normativnih kategorija zasnovanih na spolu kod univerzitetskih sportista. Ukupno 199 univerzitetskih sportista je učestvovalo u ovoj studiji, a od toga 82,9% učesnika je bilo muškog (n = 165) i 10,8% ženskog spola (n = 35). Rezultati t-testa su otkrili postojanje statistički značajne razlike između udaljenosti SPT-a (p > ,001) kod muškaraca i žena. Prikazani su percentili i rangiranje kategorijskih varijabli prema spolu uz korištenje ponderisanog prosjeka za određivanje graničnih vrijednosti percentila. Ove norme mogu biti korisne trenerima i stručnjacima iz domene rekreacije za efikasnu i jednostavnu procjenu dinamičke snage.

Ključne riječi: bacanje medicinke preko glave unazad, dinamička snaga, normativni podaci

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ANALYSIS OF THE MOST SIGNIFICANT CONTEXTUAL VARIABLES INFLUENCING THE KNOCKOUT STAGES OF THE UEFA CHAMPIONS LEAGUE

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ABSTRACT

The aim of the present study was to analyse the influence of different contextual variables in the qualifying phases of the UEFA Champions League finalists from 2000 to 2020, and study the association between the different performance indicators. The sample was composed of 232 matches from all the qualifying phases. The data was analysed through a descriptive analysis to know the characteristics of the sample; a chi-square test was used to examine the degree of association between the contextual variables, and a logistic regression to know the effect or prediction of the variables on the qualifying phase. The results showed no difference between the champion and the runner-up in each of the qualifying rounds even though the chi-square test statistic indicated a high association between scoring the first goal and winning the match in both the first and second rounds, and in each qualifying round, which ranges this probability of victory between 86% and 94%. In addition, it is noteworthy that in the first leg of the semi-finals, both finalists had a 100% chance of winning the match when they are the first to score a goal. Therefore, the main findings of this study show that the contextual variable of scoring first is the best performance indicator to predict which team will win the match and go through to the next phase of the UEFA Champions League. However, it could be confirmed that there are no other contextual variables that could differentiate the future champion and runner-up, suggesting that winning the championship is decided in the final match.

Keywords: football, contextual variables, knockout rounds

INTRODUCTION

Performance analysis is a research topic that has been the subject of great interest in recent years (García-Rubio et al., 2017) with the aim of achieving a better understanding of the factors that lead to sporting success in soccer (Carling et al., 2009; Lago, 2009; Sampaio et al., 2010; Caro et al., 2010; Fernandez-Navarro et al., 2018) and improving the results by providing the coaches with the necessary tools (Gómez et al., 2012). Thus, with particular interest for the present study, soccer research has determined that for an effective evaluation of performance indicators, it is necessary to assess the situational variables, also known as contextual, which can influence the development of a match and, consequently, its outcome. Some of these variables are the location of the match, the quality of the opponent, the state of the match or competition, and the importance of scoring the goal first (Sarmento et al., 2014; García-Rubio et al., 2015; Lago-Peñas et al., 2016; Bilek & Ulas, 2019).

Current soccer stands out for the low number of goals scored (Pratas et al., 2016), and so the relationship between scoring first and the success (winning the

match) is of increasing interest in the research field. In this sense, Lago-Ballesteros et al. (2012) state that the number of goals scored in a soccer match is the most objective measure of a team's offensive efficiency. In fact, the number of goals scored in the main European leagues (the Spanish League, Italian Calcio, Bundesliga and Premier League) are carried out by the best teams (top ranked) from these leagues, which manage to score an average of 2 goals per game, while the worst ranked teams only score 1 goal per game (Mara et al., 2012). The study conducted by Anderson and Sally (2014) indicates that the number of goals achieved in the top European leagues is 2.66. Therefore, due to the small amount of goals scored in soccer, scoring first acquires great importance (Castellano, 2009).

In addition, scoring the goal first has a direct impact on the behaviour of the teams, since they modify the style of play depending on the outcome (Caballero et al., 2017). Jones (2009) confirms that scoring a goal before the opponent can generate a positive psychological effect, which increases the probability of winning. Nevertheless, the team that does not score first suffers an adverse effect, which causes a decrease in the players' confidence and group cohesion (Bar-Eli et al., 2006). Likewise, Lago (2009) shows that whoever scores first adopts a more conservative strategy to try to reduce the opponent's chances.

Different studies have shown a positive relationship between scoring first and winning the match. Lago-Peñas et al. (2016) analysed the effect of scoring first in the 5 major European leagues. Their results showed a 73.6% probability of winning the match if the team to score first is the home team, while if the team scoring first is the away team, the probability decreases to 64.3%. The results of Michailidis et al. (2013), who studied Euro 2012, showed that the teams who scored first won over 71% of their matches, drew 22% and lost 7% in both the group and knockout stages, making no distinction between home and away. In the World Cup and the European Championship, the results were similar with a 65% probability of winning the match (Castellano-Paulis et al., 2009). In reference to the UEFA Champions League, the home teams which scored before the opponent won 76.6% of the matches, while the visiting teams that scored first won around 60% of the matches (García-Rubio et al., 2017).

In relation to the contextual variables that also influence the tactical behaviour of the teams are the state of the match, the location of the match and the quality of the opponent (García-Rubio et al., 2017). Furthermore, these same authors found a positive association between scoring first and match location in both phases of the UEFA Champions League competition, concluding that if a team plays as a home team, it increases the score by 0.48 goals, and if it scores the goal first, the score increases to 1.53 goals. However, the quality of the opponent was significant, but with an inconclusive value. On the other hand, Lago-Peñas et al. (2016) displayed data from major European leagues on achieving home advantage "quantified as the number of points won at home expressed as a percentage of all points won both at home and away". The league showing the highest home advantage was the German League (61.84%), followed by France (59.98%), England (58.17%), Spain (57.58%), and Italy (56.47%). These data may be of interest for coaches. In addition, significant differences were found in the outcome of the match depending on the quality of the opponent (Lago-Peñas et al., 2016; Lago-Peñas & Dellal, 2010).

One of the competitions that has caused great interest for performance analysis is the UEFA Champions League, the most important club competition in the world, since its competitors are the best teams of the European leagues (Lago-Peñas et al., 2011). Although research on the finalist teams (first and second place) is scarce, Szwarc (2007) analysed the match statistics between the teams that won and those who lost the UEFA Champions League finals from 1997 to 2003. He found that the main factors for winning the match were the number of shots on goal and the effectiveness of the goalkeeper's interventions.

In this study, two hypotheses are considered. Firstly, it is considered that the different contextual variables could influence the outcome of each knockout of the UEFA Champions League finalists. Secondly, a positive influence of the variable score first on the match outcome is predicted. For this reason, the aim of the present study is to analyse the different contextual variables in the knockout stages of the UEFA Champions League finalists from 2000 to the present, and to check if there is any relationship between the different performance indicators.

MATERIAL AND METHOD

Participants

The sample consisted of all matches from the knockout stages of the UEFA Champions League finalists carried out between the seasons 2000 - 2020 (both included). A total of 232 matches, which were divided into the round of sixteen, quarterfinals and semi-finals, were observed.

Instruments and Procedures

Data on match performance was obtained from the website www.resultados-futbol.com and were recorded and quantified using the Microsoft Excel 2010 tool. As an exclusion criterion, the match location in 2020 was not analysed, since they played on neutral fields due to COVID-19. In addition to this,

matches whose result ended in a goalless draw (0-0) were also excluded so as to analyse the contextual variable of scoring first.

Design

The design of the study is a cross-sectional observational investigation of the results achieved in the knockout stages of the UEFA Champions League, whose objective is entirely descriptive. The data is collected once the competition is over, and so the directionality is retrospective, and due to the nature of the data, a quantitative analysis has been applied.

Variables

The dependent variable was the final result of the elimination phases. These are divided into three categories - the round of sixteen, quarterfinals and semi-finals. Eight independent variables and their categories were used to study the associations with the outcome of the knockout round (Table 1).

Table 1. Description, definition and categories of variables.

Variable	Definition	Categories
Team	Corresponds to the team being analysed.	1. Champion. Winning team of the Champions League in that edition. 2. Runner-up. Team that loses the finals of the Champions League in that edition.
Stage	Knockout round phase.	1. Round of sixteen. First knockout round played after the group stage in the Champions League. 2. Quarterfinals. Knockout played between the winning teams of the round of sixteen. 3. Semi-final. Knockout played between the winning teams of the quarterfinals, which gives access to the finals of the Champions League.
Match location *	Refers to the venue where the match is played.	1. Away from home. The match is played at the stadium of the team not being analysed. 2. At home. The match is played at the stadium of the analysed team.
The number of goals of the analysed team *	Means the number of goals scored by the analysed team in the match.	Continuous variable
The number of goals of the non- analysed team *	Means the number of goals scored by the non-analysed team in the match.	Continuous variable
Scoring first *	Refers to the team that scores the first goal in the match.	**1.** Analysed team scores first. The team under analysis is the team to score the first goal. **2.** The team not analysed scores first. The non-analysed team is the team to score the first goal. **3.** 0-0. No goal is scored in the match.
Outcome of the match *	Determines the winner of the match.	1. The analysed team wins the match. The analysed team is the team that wins the match. 2. The team not analysed wins the match. The non-analysed team is the team that wins the match. 3. Draw. Match outcome ends in a draw.
Previous status for the second leg	Temporary advantage before the start of the second leg.	1. Home in the first leg. Home team in the first leg has home advantage after the first match of the tie. 2. Away team in the first leg. Away team in the first leg has the advantage after the first match of the tie. 3. Draw. Match ends as 0-0 so neither team has a momentary advantage.

* Variables used for both the first and second legs.

Statistical analysis

The SPSS-IBM version 23 program was used for statistical treatment of the data. A descriptive summary of the variables was made to learn about the characteristics of the sample. For all analyses, was set at 0.05 as the value for statistical significance. The relationship of the independent variables was examined by the chi-square test, and a binary logistic regression model was used to assess the effect of the contextual variables on the outcome of the elimination round.

RESULTS

Table 2 shows the descriptive measures for all the elimination rounds played. The number of goals scored by the champion and runner-up were equal for all the rounds played in both the first and second leg. In the round of sixteen, significant values (0.012) were found for the number of goals in the second leg.

Table 2. Descriptive results of the sample.

Table 2. Descriptive results of the sample.

Variable	Analysed team	n	$\bar{x}$ (SD)	Z	p
The number of goals of the team analysed in the first-leg	Champion	59	1.85 (1.57)	-0.762	0.446
	Runner-up	59	1.63 (1.29)		
The number of goals of the non-analysed team in the first-leg	Champion	59	0.63 (0.85)	-0.839	0.402
	Runner-up	59	0.75 (0.88)		
The number of goals scored by the analysed team in the second leg	Champion	57	1.89 (1.22)	-0.517	0.605
	Runner-up	57	1.79 (1.36)		
The number of goals scored by the non-analysed team in the second leg	Champion	57	0.84 (0.86)	-0.310	0.757
	Runner-up	57	0.88 (1.09)		
Round of 16					
The number of goals of the team analysed in the first leg	Champion	17	2.06 (1.44)	-1.685	0.092
	Runner-up	17	1.35 (1.32)		
The number of goals of the non-analysed team in the first-leg	Champion	17	0.94 (0.75)	-1.500	0.134
	Runner-up	17	0.59 (0.80)		
The number of goals scored by the analysed team in the second leg	Champion	17	2.24 (1.39)	-0.988	0.323
	Runner-up	17	1.88 (1.80)		
The number of goals scored by the non-analysed team in the second leg	Champion	17	0.82 (0.64)	-2.509	0.012
	Runner-up	17	0.35 (0.79)		
Quarterfinals					
The number of goals of the team analysed in the first leg	Champion	21	2.10 (1.90)	-0.495	0.621
	Runner-up	21	1.71 (1.45)		
The number of goals of the non-analysed team in the first-leg	Champion	21	0.57 (0.81)	-0.988	0.323
	Runner-up	21	0.90 (1.09)		
The number of goals scored by the analysed team in the second leg	Champion	20	1.90 (1.12)	-0.787	0.431
	Runner-up	20	1.60 (1.14)		
The number of goals scored by the non-analysed team in the second leg	Champion	20	0.85 (0.99)	-0.369	0.712
	Runner-up	20	0.80 (1.15)		
Semi-finals					
The number of goals of the team analysed in the first leg	Champion	21	1.43 (1.29)	-0.685	0.494
	Runner-up	21	1.76 (1.41)		
The number of goals of the non-analysed team in the first-leg	Champion	21	0.43 (0.93)	-1.897	0.058
	Runner-up	21	0.71 (0.72)		
The number of goals scored by the analysed team in the second leg	Champion	20	1.60 (1.14)	-0.881	0.378
	Runner-up	20	1.90 (1.17)		
The number of goals scored by the non-analysed team in the second leg	Champion	20	0.85 (0.93)	-1.715	0.086
	Runner-up	20	1.40 (1.05)		

Table 3 displays the results of the chi-square test (χ^2) and its measure of association. The probabilit and runner-up. In the round of sixteen, significant values are only found in the second leg, where the association between scoring the first goal and winning the match is 96.2%. Similar results were found for the other elimination rounds (quarterfinals and semi-finals), highlighting the first leg of the semi-finals where the finalists who scored the first goal won the match 100% of the times. As for the second leg of the same round, this percentage drops to 77.3%.

Differentiating between UCL finalists and their rivals, the finalist team that scores the first goal has an 86.5% - 93.9% probability of winning the match, while the rival that scores the first goal only has a 40% - 50% probability of winning. These values are similar for all rounds; nonetheless, in the second leg of the round of sixteen, the rival teams which score first have a 60% probability of winning the match.

Table 3. Chi square results and relative percentages.

Table 3. Chi square results and relative percentages.

	Variable	Analysed team n (%)	Team not analysed n (%)	Global n (%)	χ^2 (p) (gl = 2)
First leg	Scoring first in the first leg and winning the match	73 (91.4)	27 (40.7)	100 (75.0)	26.28 (< 0.001)
	Scoring first in the first leg and winning the match (Champion)	36 (88.9)	12 (25.0)	48 (72.9)	5.81 (0.055)
	Scoring first in the first leg and winning the match (Runner-up)	37 (86.5)	15 (53.3)	52 (76.9)	21.51 (< 0.001)
Second leg	Scoring the first goal in the second leg and winning the match	73 (90.4)	32 (50.0)	105 (78.1)	48.41 (< 0.001)
	Scoring the first goal in the second leg and winning the match (Champion)	40 (87.5)	15 (46.7)	55 (76.4)	28.47 (< 0.001)
	Scoring the first goal in the second leg and winning the match (Runner-up)	33 (93.9)	17 (52.9)	50 (80.0)	23.52 (< 0.001)
Round of sixteen	Scoring first in the first leg and winning the match	17 (88.2)	11 (27.3)	28 (64.3)	7.25 (0.027)
	Scoring the first goal in the second leg and winning the match	26 (96.2)	5 (60.0)	31 (90.3)	20.20 (< 0.001)
Quarterfinals	Scoring first in the first leg and winning the match	31 (77.4)	7 (42.9)	38 (71.1)	3.86 (0.145)
	Scoring the first goal in the second leg and winning the match	25 (96.0)	11 (45.5)	36 (80.6)	14.14 (0.001)
Semi-finals	Scoring first in the first leg and winning the match	25 (100.0)	9 (55.6)	34 (88.2)	24.49 (< 0.001)
	Scoring the first goal in the second leg and winning the match	22 (77.3)	16 (50.0)	38 (65.8)	15.90 (< 0.001)

Finally, a logistic regression test was performed on the contextual variables that could predict (odds ratio) the champion of this competition. The champion predictions of results showed no significance level ($p < .05$) with the number of goals, location (home or away), previous status (in case of obtaining advantage in the first leg), and the method of classification (if it is in regular time or if it required extra time or penalties).

DISCUSSION

The aim of this study was to analyse the different contextual variables in the knockout stages of the UEFA Champions League finalists from 2000 to the present, and to examine whether there is any relationship between the different performance indicators. As for the main results found, they allow us to support the relevance of scoring a goal first to win a match. Specifically, the probability of winning the match by scoring the first goal ranges between 86.5% and 93.9%. Furthermore, it is important to note that no significant differences are found in each knockout round between the champion and runner-up in terms of the number of goals. However, to our knowledge, there is no previous research that analyses the contextual variables of the knockout rounds of the UEFA Champions League finalists.

The results of our study coincide with those obtained by Lago-Peñas et al. (2016), who observed values between 64.3% and 73.6% probability of winning the match when scoring the first goal, confirming a positive association between these variables in the main European leagues. Likewise, in relation to this association, the results obtained in Euro 2012 show a 71% probability of winning the match by managing to score the first goal (Michailidis et al., 2013). Furthermore, about the UEFA Champions League, García-Rubio et al. (2017) also showed significant values ranging between 60% and 76.6% probability of winning the match, depending on whether the team plays as home or away. As already mentioned, these values coincide with those of the present study even though there is a significant difference in the probability of winning the match if they score the first goal, since the results obtained in our study are above 85%.

Notwithstanding, Coso et al. (2020) analysed the champion and runner-up of the Spanish League and found significant differences in the champion achieving a higher number of away goals and a lower number of home goals conceded. In our study, no differences were found in this contextual variable between the champion and runner-up. In soccer, a sport in which there are no more than three goals scored on average per match, Anderson and Sally (2014) justify that scoring first acquires relevance to the outcome. In this sense, the results obtained support the hypothesis of Jones (2009), in which the team scoring before its opponent generates a positive psychological effect, thus increasing the chances of winning the match. In addition, the state of the match influences the tactical behaviour of the teams; for example, teams that are losing decrease direct play so that ball possessions are longer and increases the likelihood of making unforced errors, while the team that is winning increases direct play and counterattacks, focusing attention on maintaining that advantage (Fernandez-Navarro et al., 2018).

On the other hand, unlike the research conducted by García-Rubio et al. (2017) and Lago-Peñas et al. (2016), in which they find positive associations between match location and opponent quality on match outcome, no significant evidence in relation to contextual variables, such as match location, opponent quality and previous status (goal advantage for the second leg of the second leg), on the matches played by the finalists of this competition was found in the present study. However, these variables should be taken into account as other research has shown their influence on both the tactical behaviour of the teams and the outcome of the match.

As for the limitations of the study, the obtained results should be analysed taking into account all the teams participating in the UEFA Champions League, examining whether there are differences between the finalists and the rest of the teams. On the other hand, the sample of the number of goals scored could be larger to assess whether more significant evidence occurs. As a proposal for future research, it would be interesting to analyse match-related statistics such as the number of shots, shots on goal, effectiveness of passes, possessions, etc. A study of the matches played during the group stage could also be carried out to see if the effect of scoring first varies with respect to the knockout stage.

CONCLUSIONS

In conclusion, this study demonstrates the effect of scoring first on the results of the knockout stages of the UEFA Champions League, thus justifying that it is the best performance indicator. Likewise, the team that scores first increases the chances of winning the match or even classifying for the next round. Finally, the results show no differences between the champion and runner-up in the contextual variables evaluated, suggesting that winning the championship title is decided in the last match.

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ANALIZA NAJZNAČAJNIJIH KONTEKSTUALNIH VARIJABLI KOJE UTIČU NA ELIMINACIONE FAZE FINALISTA UEFA LIGE PRVAKA

Cilj ove studije je analizirati uticaj različitih kontekstualnih varijabli u kvalifikacijskim fazama finalista UEFA Lige prvaka od 2000. do 2020. godine te istražiti povezanost između različitih indikatora učinka. Uzorak se sastojao od 232 utakmice iz svih kvalifikacijskih faza. Podaci su analizirani putem deskriptivne analize kako bi se identifikovale karakteristike uzorka; hi-kvadrat test je korišten za ispitivanje stepena povezanosti između kontekstualnih varijabli, a logistička regresija za upoznavanje sa efektom ili predviđanjem varijabli za kvalifikacijsku fazu. Rezultati nisu pokazali razlike između prvaka i drugoplasiranog u svakom kvalifikacijskom kolu iako je hi-kvadrat statistički test ukazao na visoku povezanost između postizanja prvog gola i pobjede na utakmici tokom prvog i drugog kola te u svakom kvalifikacijskom kolu, a gdje je opseg vjerovatnoće za pobjedu između 86% i 94%. Nadalje, treba napomenuti da su u prvoj fazi polufinala oba finalista imala 100% šansu za pobjedu na utakmici nakon što prvi postignu gol. Prema tome, glavni pronalasci ove studije pokazuju da kontekstualna varijabla postizanja prvog gola jeste najbolji indikator učinka za predviđanje tima koji će pobijediti na utakmici te proći u narednu fazu UEFA Lige prvaka. Međutim, može se potvrditi da ne postoje druge kontekstualne varijable koje bi mogle ukazati na razliku između budućeg prvaka i drugoplasiranog, a što upućuje na to da se pobjednik prvenstva odlučuje u završnoj utakmici.

Ključne riječi: : fudbal, kontekstualne varijable, eliminaciona kola

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A FLASHBACK TO THE EFFECT OF TOP-LEVEL SOCCER GOALKEEPERS' TACTICS ON THEIR TEAM'S ATTACK

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ABSTRACT

As soccer is constantly developing, changes in players' technical and tactical behaviour are to be expected. This is mainly the result of new coaching styles as well as external factors, such as minor regulation changes, or possibly due to the introduction of technology in major events (such as the use of VAR in the 2018 World Cup). Given that in international literature there are only a few studies on the goalkeeper and his offensive tactics, the present study draws on the past, selecting as a sample the goalkeepers of the four finalist teams in the World Cup of 2014. Hence, the purpose of the present study was to record the goalkeeper's offensive tactics after ball possession and investigate how they affected the development of their team's attack. Another objective was to create a database that could be compared against the respective goalkeeper tactics in the World Cups of 2018 and 2022 where VAR technology was the predominant change. The recorded parameters consisted of the goalkeeper tactics, the goalkeeper's actions with the ball, the field zone, the type of attack, the in-game situation, and the perspective of the attack. The games were observed with the use of the SportScout software, while the statistical processing was performed using the Crosstabs Analysis and the chi-square significance test. The results showed that the goalkeeper's 'transition to attack' (TTA) tactics tended to result in more promising attacks, although there was no significant difference in the frequency of use compared to the 'no transition to attack' (NTA) tactics.

Keywords: performance analysis, soccer, goalkeeper actions

INTRODUCTION

The historical evolution of the goalkeeper started in 1863, with the introduction of the corresponding position. Height was the primary criterion for the appointment of a player to the goalkeeper's position, while substitutions appeared a few years later. The development of the goalkeeper's role appears to have been largely influenced by the evolution of the game rules, such as set-pieces (corner kicks, penalty kicks), the offside rule, etc. Nowadays, goalkeepers may sprint outside the penalty area in order to interrupt an attack by the opposing side, while at the same time, most of them are quite good at controlling the ball with their feet. Moreover, when the team is defending, apart from protecting the goal, the goalkeepers organise their teammates (FIFA, 2010). As a result, the goalkeeper's position requires particular attention and special training programmes (FIFA, 2010). This was the focus of research conducted by Otte et al. (2020), which showed that decision-making skills, physical ability, mentality, and technical abilities are considered to be a goalkeeper's essential characteristics that need to be developed in training.

Furthermore, the same authors (Otte et al., 2020) found that, as a general rule, the goalkeepers were not included in most research studies focusing on football match analysis. It was also mentioned that this is possibly due to the different skills used by the goalkeeper, compared to other players. However, there are individual studies related to goalkeepers that examine their physical characteristics, their motor skills and their physical condition (Rogan et al., 2011;

Rebelo et al., 2012; Cossio-Bolanos et al., 2012; Masocha and Katanha, 2014; Santos et al., 2018).

As for the goalkeeper's technical and tactical behaviour, most studies analysed their defensive abilities during opponent attacks (Salvo et al., 2008; Sainz De Baranda et al., 2008; Liu, et al., 2015). However, over the past several years, apart from his defensive role, the goalkeeper has participated in the attacking play of his team. A review of international literature shows that the goalkeeper's 'attacking' role has not been studied in full. Very often, the goalkeepers are seen employing transition-to-attack tactics, i.e., creating the right conditions for a counterattack or an organised attack by their team, by passing the ball quickly and accurately to a teammate. It is also common to see the goalkeeper pass the ball intentionally to a teammate after making a save in order for the team to retain ball possession and start an immediate attack (Kollias, 2005). The questions being raised in the present study are how often the goalkeeper employs the transition-to-attack tactics during the game, in what way, and whether the specific tactics can affect any elements of the team's attack such as the evolving playing style or even the prospect of each attack.

Hence, the purpose of the current study was to record the goalkeeper's attacking tactics after ball possession and investigate its effects on the development of their team's attack. The second objective was to create a database that could be compared against the respective goalkeeper tactics in the 2018 World Cup where VAR technology, the predominant change, could bring about changes in the team's, and potentially the goalkeeper's, in-game behaviour.

METHOD

Sample

The sample of the research comprised the goalkeepers who participated in the 2014 Football World Cup in Brazil and whose teams reached the final stage of the competition (Germany, Argentina, the Netherlands, and Brazil). A total of 451 goalkeeper actions were observed, occurring after gaining ball possession. In accordance with the second objective of the current study, one of the selection criteria of the sample was that the matches to be analysed were played at the top level, prior to the introduction of VAR. Although the research team acknowledged the fact that there were also experienced, top-level goalkeepers in other teams, such as those of Italy, France etc., they opted to study the goalkeepers of the teams that made the final four in order to obtain the most homogeneous characteristics possible. More specifically, their teams reached the finals, and the goalkeepers under observation had the same years of experience (48 matches on average), with the exception of the Italian goalkeeper, who had only played in 8 matches before the 2014 World Cup, which constitutes a limitation of the present study. Moreover, the number of actions they participated in was approximately the same.

Data collection measuring instruments

The observation protocol consisted of the following parameters:

Goalkeeper tactics:
1) Transition to attack (the goalkeeper's defensive action and his movement with the ball were performed in such a manner that his participation at the beginning of the attack is considered important), e.g., catching the ball and passing it quickly to a teammate and deflecting or passing the ball to a teammate intentionally,

2) No transition to attack (simple movement with the ball).

Possession of the ball (possession after the goalkeeper's action):
1) teammate
2) opponent

Goalkeeper actions with the ball:
1) Ball distribution - ball throw (the goalkeeper makes a pass with his hand to a teammate)
2) Goal-kick
3) Long kick-passing (the goalkeeper makes a long high pass by kicking the ball to a teammate).
4) Low-driven pass (the goalkeeper distributes the ball, which stays close to the ground, to a nearby teammate)
5) Volley
6) Ball clearance to a teammate (e.g., punch)
7) Ball clearance to the opponent (e.g., punch)

Field zone (Figure 1): (the field zone of the ball distribution by the goalkeeper):
1) 1st quarter of the field (zone 1)
2) 2nd quarter of the field (zone 2)
3) 3rd quarter of the field (zone 3)
4) 4th quarter of the field (zone 4)

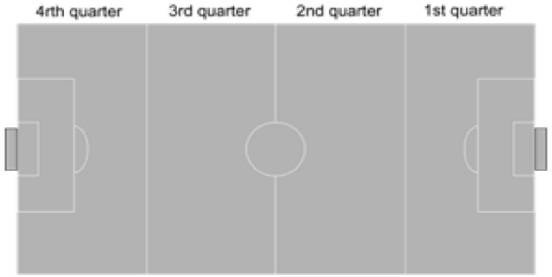

Figure 1. Field zone

In-game situation: (the in-game situation that was created by the goalkeeper's action):
1) Organized attack
2) Counterattack
3) Attack interrupted by the opponent
4) No attack

Attack potential: (whether the goalkeeper's tactics resulted in attacks that were either completed or led to set-piece situations such as a corner kick or a direct kick):
1) Yes
2) No

Data collection of every goalkeeper's offensive action, along with the relevant parameters, was performed using the SportScout 3.2 video-analysis software; the recording of each attempt started when the goalkeeper gained possession of the ball and ended when his teams' attack was completed (successful and unsuccessful) or when the attack was incomplete (the ball ended up in the possession of the opposing player, ball out of field, etc.). The observation protocol was drawn up with the assistance of a high-level football trainer who instructed the observer in recognising the necessary parameters during match observation. The reliability of the recorded data was checked using the intra-observation agreement with which both the trainer and the observer recorded 50 goalkeeper's offensive actions separately, using the same analysis parameters. As shown by Cohen's Kappa value, the parameters were recorded correctly by the observer (k = 1.000 for all parameters). Consequently, to ensure that the observer would register all the attacks correctly, another 50 selected offensive actions were observed. After one week, the same observation was repeated. In both cases, the Cohen's Kappa value was exceptionally high (k = 1.000).

ANALYSIS

Data analysis was performed using the SPSS statistical software platform. Crosstabs Analysis and the chi-square test of significance index were used to check the relationship between the tactics used by the goalkeeper and the parameters referred to in the observation protocol. In cases in which even one of the expected values was lower than 0.5 (i.e., the conditions of statistical analysis were not met), the value of the Fisher method (Fisher's exact test) was taken into account.

RESULTS

As for the tactics used by the goalkeepers (GK) of the sample, it was found that 56% were 'transition to attack' tactics (TTA), that is, the goalkeeper played an active role in the attack, while 44% were 'no transition to attack' (NTA) tactics, in other words, regular attacks that included either passing the ball to a teammate or a goal kick (Figure 2). It was also found that, in 100% of the actions performed in the TTA tactics, the ball ended up in the possession of a teammate, while the NTA tactics had a lower success rate of 76% (Table 1).

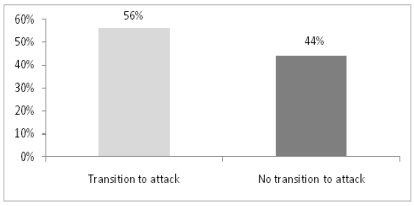

Figure 2. Goalkeeper tactic

Concerning the goalkeeper's actions during his 'transition-to-attack' tactics (Table 1), it was found that a 'hand pass' had the highest rates (58%), while 'a low-driven pass' added up to 13%, 'volleys' to 12% and 'Ball clearance to a teammate' to 7%. On the other hand, in the 'no-transition-to-attack' tactics, the most common action of the goalkeeper was the 'goal kick' (63%). According to the value of the chi-square (7) = 456.2, $p < .001$, the goalkeeper's actions were largely influenced by the tactics he employed.

As for the 'in-game situation' employed by the goalkeeper's side, it was found that for the most part, these were organised attacks, while 86% of them were performed following the goalkeeper's TTA tactics. Although counterattacks show a lower percentage, most of them (12%) were carried out following the employment of TTA tactics (Table 1). The value of the chi-square (3) = 26.35, $p < .001$ showed that the type of attack performed by the goalkeeper's side depended on his tactics.

Overall, the attacks performed by the goalkeeper's side were 'promising attacks'. However, this was significantly dependent upon the goalkeeper's tactics (chi-square (1) = 5.70, $p > .05$). More specifically, 91% of the 'promising attacks' were performed after TTA tactics and 84% after NTA tactics. Moreover, most "non-promising attacks" (16%) were, for the most part, executed after NTA tactics (Table 1).

Table 1. Percantages of goalkeeper offensive behaviour

Table 1. Percantages of goalkeeper offensive behaviour

CATEGORY	PARAMETERS	(TTA)	(NTA)
Possesion of the ball	Teammate	100%	77%
	Opponent	0%	23%
Goak keeper action with the ball	Hand pass	58%	1%
	Goal kick	6%	63%
	Low-driven pass	13%	1%
	Long kick-passing	2%	0%
	Volley	12%	0%
	Ball clearance to a teammate	7%	0%
	Ball clearance to the opponent	0%	15%
	No participation in particular action	2%	21%
In game situation	Organised attack	86%	74%
	Counterattack	12%	1%
	Attack interrupted by the opponent	2%	24%
	No attack	1%	1%
Attack potential	Yes	91%	84%
	No	9%	16%

Concerning the target field zone of the goalkeeper's actions, it was found that, in 'transition-to-attack' tactics, 61% of the 'hand pass' ended in zone 1, while 35% ended in zone 2 (Table 2). Moreover, the majority of 'low-driven passes', such as 'clearances to teammates' also ended in 'zone 1' (82%), whereas 'volleys' usually ended in zone 3 of the field (87%). As for 'free kicks', the most frequent type of 'no-transition-to-attack' actions, it was found that in 45% of the cases, they ended in 'zone 3' of the field, while 45% ended in 'zone 1'. The value of the chi-square (21) = 233.8, $p < .001$ indicated that the ending zone of the goalkeeper's actions was relevant to the tactics that he employed (transition to attack or not) as well as to its respective actions.

Table 2. The relationship between the goalkeeper's actions and the field zone (TTA and NTA)

	FIELD ZONE							
	1st quarter of the court		2st quarter of the court		3st quarter of the court		4st quarter of the court	
GOALKEEPER´S ACTION WITH THE BALL	**TTA**	**NTA**	**TTA**	**NTA**	**TTA**	**NTA**	**TTA**	**NTA**
Hand pass	61%	100%	35%	0%	5%	0%	0%	0%
Goal kick	57%	44%	0%	5%	36%	45%	7%	6%
Low-driven pass	82%	100%	15%	0%	0%	0%	3%	0%
Long and high pass to a teammate	0%	0%	0%	0%	83%	0%	17%	0%
Volley	0%	0%	0%	0%	87%	0%	13%	0%
Ball clearance to a teammate	78%	0%	11%	0%	11%	0%	0%	0%
Ball clearance to the opponent	0%	77%	0%	20%	0%	3%	0%	0%

As for the in-game situation that was created by the goalkeeper's action with the ball, it was found that, when the 'transition-to-attack' tactics was used, the majority of the 'hand passes' (88%) resulted in organised attacks, while 12% led to 'counterattacks'. Also, 'organised attacks' were developed following 'low-driven passes' (100%), as well as volleys, in which case 73% resulted in an 'organised attack', and the other 23% led to 'counterattacks'. Concerning the 'goal kick', the most frequent goalkeeper's action, in the case when the 'no-transition-to-attack' was employed, the majority (94%) also resulted in 'organised attacks' (Table 3). The value of the chi-square (21) = 311.56, $p < .001$ showed that the created in-game situation following the goalkeeper's action was significantly dependent on both the tactics that he employed and the corresponding actions.

Table 3. The relationship between the goalkeeper's actions and the in-game situation (TTA and NTA)

	IN-GAME SITUATION							
	Organised attack		Counterattack		Attack interrupted by the opponent		No attack	
GOALKEEPER´S ACTION WITH THE BALL	TTA	NTA	TTA	NTA	TTA	NTA	TTA	NTA
Hand pass	88%	100%	12%	0%	0%	0%	0%	0%
Goal kick	0%	94%	0%	1%	7%	4%	0%	2%
Low-driven pass	100%	100%	0%	0%	0%	0%	0%	0%
Long and high pass to a teammate	100%	0%	0%	0%	0%	0%	0%	0%
Volley	73%	0%	23%	0%	3%	0%	0%	0%
Ball clearance to a teammate	67%	0%	22%	0%	11%	0%	0%	0%
Ball clearance to the opponent	0%	0%	0%	3%	0%	97%	0%	0%

DISCUSSION

As already stated, the purpose of the present research was to study the goalkeeper's tactics after ball possession and to investigate the extent to which the employed tactics affected the attack of his team. The corresponding observation protocol distinguishes between two types of tactics, 'transition to attack' (TTA) and 'no transition to attack' (NTA). Apart from the goalkeeper's actions with the ball, the observation protocol contains additional parameters, such as the field zone, the type of attack etc., in order to provide further information concerning the possible influence of his gaming behaviour on the attack of his team.

In modern football, coaches usually distinguish among four game situations. These are: retaining ball possession, stealing the ball, attack-to-defence transition, and defence-to-attack transition. These two types of transitional play may have an impact on the game, and in the case of fast defence-to-attack transitions, they can create favourable conditions that can be exploited by the players (Vogelbein et al., 2014). According to FIFA (2010), the goalkeeper now plays an active role in the team's offensive actions, as it is shown that he plays an increasingly important role in the initiation of attacks. This is also verified by the results of the present study, where the goalkeepers demonstrated a tendency to employ 'TTA' rather than 'NTA' tactics. However, we should bear in mind that the tactics employed by the goalkeeper after gaining ball possession depend on various factors that are common in all games such as pressing by an opponent, the position of teammates in the pitch, the current score, etc. Therefore, it seems that all the goalkeepers in the sample, using their experience in relation to these factors, contributed significantly to the attack, whenever possible. The quick assessment of the current in-game situation and the ability to spot a teammate in a favourable attacking position as well as to identify the vulnerable areas in the opponent's defence are skills required from a goalkeeper so as to 'unfold' the attacking play of his side (Kollias, 2005).

As for the effectiveness of the actions included in 'TTA' tactics, it was found that, for the most part, they were successful (ending up to a teammate), as opposed to the lower success rate in the case of 'NTA' tactics. More specifically, it was found that the actions used by goalkeepers during 'TTA', such as a hand pass, low-driven passes, volleys, and even the manner of fending off shots by the opponent, were targeted and quick. Additionally, taking into account the field zone where the goalkeeper sent the ball, it was found that relatively short passes to teammates (zones 1 and 2) created favourable conditions for quick attack build-ups, as well for retaining possession of the ball. After all, this is what top teams attempt to achieve in order to be able to control the opponent side (Collet, 2013). On the other hand, though targeted, ball distributions performed by a goal kick (the most common NTA action) were less likely to end in ball possession by a teammate due to distance (usually ending in zones 3 and 4). However, it remains an action that can, on the one hand, move the ball past the halfway line easily and quickly and, on the other, requires smaller effort from the team.

According to Sainz DeBaranda et al. (2008), goalkeepers can play a significant role in the choice of tactics employed by their team as well as in the build-up of the attack. Indeed, it was found in the present study that, regardless of the goalkeeper's tactics, the type of the attack employed by his team was the organised attack. However, the present study found differentiation in the counterattacks, most of which, although fewer than the organised ones, were

developed following the TTA tactics. The main goal of the TTA tactics employed by the goalkeepers of the sample may actually have been to create counterattack situations, which requires the identification of vulnerable spots in the opposing team in order to create more dynamic attacking build-ups and cause problems to the opposing defence (FIFA, 2010).

Finally, the positive effect of the TTA tactics on the attacks that were created by the teams of the goalkeepers in the sample as a whole is further supported by the fact that most incomplete attacks were developed following the TTA tactics. It is thus evident that the goalkeeper is actively involved in the attacking play of his team, where he assumes the role of the 'libero', as he also does during defensive play (FIFA, 2010).

To sum up, the conclusions drawn from this paper show that the top goalkeepers under study employed TTA and NTA tactics to an approximately equal degree (50-50). As was to be expected, the actions they used in TTA tactics were more efficient, as they were performed with greater accuracy and in the zones of the first half of the field. Moreover, the attacks of their teams as a whole had favourable perspectives, although most of those that were not concluded occurred following the goalkeeper's NTA tactics. Therefore, although there does not appear to be a significant difference in the frequency of use between the TTA and NTA tactics, the former exhibited a trend to result in more promising attacks by the goalkeeper's team.

CONCLUSION

Although indicators, and performance in general, may vary from one game to another (O'Donoghue, 2005), they can provide evidence for a large part of the top goalkeepers' attacking behaviour. This can provide football coaches with important information that they can use in the training sessions of their teams. Moreover, they can use the parameters under investigation in order to evaluate the attacking tactics employed by their goalkeeper and the way it can affect the build-up of their team's offensive play. Moreover, most of the time, performance in sports is affected by the evolution of the sport itself (improved training programmes for the development of technical skills and physical fitness) as well as by external factors, such as minor changes in the regulations, and possibly the introduction of technology such as the use of VAR (Meja, 2013). This could also affect both the goalkeeper's defensive and offensive actions. Given the small number of studies on goalkeepers' behaviour, it is therefore proposed that the study of matches from the 2018 and 2022 World Cups be continued. This would result in the recording of their technical and tactical behaviour, and also in the assessment of any data originating from the use of VAR, immediately following its introduction as well as in later stages (2022 World Cup), when both teams and players are better adapted to it.

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RETROSPEKCIJA UČINKOVITOSTI TAKTIKA VRHUNSKIH GOLMANA NA NAPAD NJIHOVIH TIMOVA

Kako se fudbal neprekidno razvija, tako su i očekivane promjene u tehničkom i taktičkom ponašanju igrača. Ovo je uglavnom rezultat novih trenažnih stilova i eksternih faktora poput manjih promjena pravila ili je to možda prouzrokovano uvođenjem tehnologije na velike manifestacije (kao što je korištenje VAR-a na Svjetskom prvenstvu 2018. godine). Obzirom da u međunarodnoj literaturi postoji samo nekoliko studija o golmanima i napadačkim taktikama, trenutna se studija oslanja na prošlost te kao uzorak uzima golmane četiri tima koji su bili finalisti Svjetskog prvenstva 2014. godine. Prema tome, svrha ove studije je zabilježiti napadačke taktike golmana nakon posjeda lopte te ispitati kako one utiču na razvoj napada njihovog tima. Dodatni cilj je kreirati bazu podataka koja bi se mogla uporediti sa odgovarajućim taktikama golmana na Svjetskim prvenstvima 2018. i 2022. godine, a gdje je korištenje VAR tehnologije dominantna promjena. Zabilježeni parametri su sadržavali taktike golmana, njihove aktivnosti sa loptom, zonu terena, vrstu napada, situaciju tokom utakmice i poziciju napada. Utakmice su posmatrane korištenjem SportScout softvera, a statistička obrada je provedena pomoću Crosstabs analize i hi-kvadrat testa značajnosti. Rezultati su pokazali da golmanova taktika - napadačka tranzicija (TTA) obično dovodi do obećavajućih napada, iako ne postoji značajna razlika u učestalosti korištenja naspram taktike tokom koje se ne vrši napadačka tranzicija (NTA).

Ključne riječi: analiza učinka, fudbal, akcije golmana

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APPLIED RESEARCH ON EXERCISES TO IMPROVE PHYSICAL FITNESS OF MALE COLLEGE FOOTBALL TEAMS

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ABSTRACT

Football is called the king of sports because it is so attractive and full of surprise. The sport has inspired a lot of people to practice and compete for better health and comprehensive development. At colleges, football is particularly of interest as an exercise for students to enhance wellness, create a comfortable atmosphere and reduce stress after class. However, in fact, physical strength is still an issue of Vietnamese football players and students. They often get exhausted at the end of the competitions, and hence their performance is greatly impacted. This study is aimed at exercises to improve physical fitness of college football teams, contributing to quality enhancement in training and competition and working as a reference to advance football coaching at a college level. We carried out assessment tests before and after training and compared the results to identify research factors, including general and professional physical strength. The selected tests are standing long jump, standing high jump, 100-metre run, 30-metre sprint from a four-point starting position, Cooper test, 5x30m sprints, and 20-metre zig-zag run. The study results show that after 8 months of training, players' physical strength has been remarkably improved, demonstrating the effectiveness of the selected exercises.

Keywords: football, physical fitness, performance

INTRODUCTION

Football has high requirements of techniques, strategies, physical fitness, and mental health. As a football match normally lasts 90 minutes, physical development plays a special and fundamental role to perform techniques and strategies, as well as improve players' performance. In fact, football development at colleges still has a long way to go as it has not met the current requirements, especially in improving players' physical strength (Gallo et al., 2016; Iaia et al., 2009; Bogdan et al., 2019; Seo et al., 2018; Markovic & Ivovic, 2021). Corbett et al. (2018) developed a physical and technical training system for Australian football, and the result was able to support football coaching. Jiang (2018) gave a simple overview about players' stamina, explained the inner relationship and core power, and emphasised its importance in three aspects: effective coordination of muscle groups, enhancement of muscle sensitivity and damage avoidance; hence, he discussed the training methodology based on training focus. Rebelo et al. (2014) analysed young players' physical capacity in relation to their match performance. The study pointed out that young football players had a high heart rate during a match, and their running efficiency reduced as the match came to the end. Özgünen et al. (2010) studied the impact of hot environment on football players' physical activities, especially their heat reaction. They found out that during matches in high temperature and humidity, players' physical efficiency can reduce due to high heat stress. Meister et al. (2013) indicated that high match exposure time of elite football players in three weeks does not affect their mental wellness and performance. So far, there have been a number of studies on the importance of improving football players' physical strength, especially in college teams (Kubik et al., 2005; Pope et al., 2014; Azzarito, 2009; Parnell et al., 2017).

Aiming at developing male players' physical strength in college football teams, we offer a mix of exercises, make comparisons after one year of training, and then assess the effectiveness of the training method, contributing to quality enhancement in training and competition and working as a reference to advance football coaching at a college level.

METHODS

In the study, we carried out assessment tests before and after training and compared the results to identify research factors, including general and professional physical strength. The selected tests are standing long jump, standing high jump, 100-metre run, 30-metre sprint from a four-point starting position, Cooper test, 5x30m sprints, and 20-metre zig-zag run. The study was carried on the male football team of Tien Giang University, Vietnam. Based on the curriculum, students' training time and the system of selected exercises, we built up an experimental plan for 24 students of Tien Giang University from September 2017 to April 2018. The duration was 34 weeks, with two training sessions/week on Wednesday and Friday. The total number of sessions was 68, and each session lasted 90 minutes. For all the students who participated in the research, the research process was explained in writing and verbally, and they filled out the informed consent form. We used a descriptive statistical method to analyse the collected data. $P < 0.05$ was considered as the level of significance.

STANDING LONG JUMP

The test is used to assess the aggregate explosive strength of lower limbs' muscle groups and back muscle, leg resilience and smooth coordination of the whole body. The participant stands with the feet shoulder-width apart right behind the line, crouches deep and low on spot, and then stomps on the ground with the whole body's strength, particularly legs, while swinging his hands from above to the back and then to the front in order to take the body off into the air. The participant lands with knees down, using impulsive force to counter impact force and swinging his hands from above to the back and then to the front to keep balance. The result is measured in metres from the start line to the first touch point of the heel with the ground (measured in a straight line). It is performed three times, and the time with the best performance is recorded.

STANDING HIGH JUMP

The test is used to assess resilience, which is the players' ability to resist the gravity on their bodies by using whole-body strength. Like the long jump, with a good high jump, a player can do heading better and a goalkeeper can catch the ball in the air better. The participant stands facing the wall, raising the preferred hand straight above the head to identify the height of hand reach. The participant then dips the hand in white powder, crouches on spot to jump high, and touches the wall to mark the height of the jump. The difference between the heights of the hand reach and the jump is the on-spot jump distance. It is performed three times, and the time with the best performance is recorded. The result is measured in metres.

30-METRE SPRINT FROM A FOUR-POINT STARTING POSITION

The test is used to assess the players' speed and ability to move at the highest speed. The participant is in a four-point starting position at the start line. Upon getting the starting signal, the participant quickly leaves the start line and runs fast to cross the finish line. The examiner stands at the finish line, starts the stopwatch with the starting signal and stops it when the runner touches the plane perpendicular to the finish line. The result is measured in seconds, and performed once.

100-METRE RUN

The test is used to assess the players' speed. The participant is in a four-point starting position at the start line. Upon getting the starting signal, the participant quickly leaves the start line and runs fast to cross the finish line. The examiner starts the stopwatch with the starting signal and stops it when the runner touches the plane perpendicular to the finish line. It is performed twice, and the time with better performance is recorded.

5 X 30M SPRINTS

The test is used to assess the players' speed and skilfulness. Students are divided into groups of 5. It is performed one person at a time, and the stopwatch starts with the participants in a four-point starting position leaving the start line and stops when they cross the finish line. The participants run 5 times with a break of 20 seconds between runs. The result is the total time of 5 runs (breaks are not included).

COOPER TEST

The test designed by Dr. Cooper (1971) is used to assess the students' physical capacity within 12 minutes of running, the capacity of the circulatory system and aerobic fitness (endurance). The longer distance the students run in 12 minutes, the better their physical fitness is. The participants warm up first, and then stand at the starting point. Upon getting the starting signal, they run for 12 minutes. The running distance of each student is then measured

20-METRE ZIG-ZAG RUN

The test is used to assess the players' speed and skilfulness. Skilfulness is the motive element that helps people to quickly and easily acquire new moves. The way to perform is shown in Figure 1. The participant is in a four-point starting position at the start line. Upon getting the starting signal, the participant quickly leaves the start line, quickly and skilfully runs among cones, and then runs straight back to the finish line. The examiner starts the stopwatch with the starting signal and stops it when the runner touches the plane perpendicular to the finish line. The result is measured in seconds, and performed once.

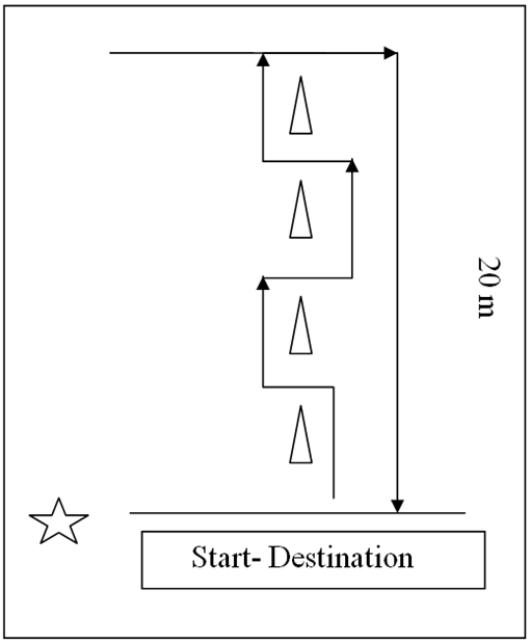

Fig. 1. 20-metre zig-zag run

RESULTS

After the training, the 24 participants were equipped with basic professional competence and good physical foundation. We carried out tests to assess their physical strength. The results are presented in Table 1 and Figure 2. As it can be seen, after the training, the test values of the Tien Giang University male football players' physical fitness had increased.

Table 1: Results of Tien Giang University male football team's physical fitness after 8 months of training.

Test	Before		After		W (%)	t	p
	X	S	X	S			
Standing long jump (cm)	226	13.3	240	13.92	6.17	10.05	< 0.05
Standing high jump (cm)	47	4.82	52	3.89	10.72	12.14	< 0.05
100-metre run	12.62	0.33	12.10	0.27	4.21	11.58	< 0.05
30-metre sprint from a four-point starting position (s)	3.66	0.16	3.53	0.12	3.49	9.06	< 0.05
Cooper test (m)	2512	77.19	2582	75.70	2.59	19.45	< 0.05
5x30m sprints (s)	20.70	0.99	20.40	1.01	1.25	4.53	< 0.05
20-metre zig-zag run (s)	4.21	0.39	4.13	0.37	2.73	6.15	< 0.05

Note: X is the average value, S is the standard deviation, W is the growth rate, t is the test value of 2 related samples, and p is the correlation coefficient

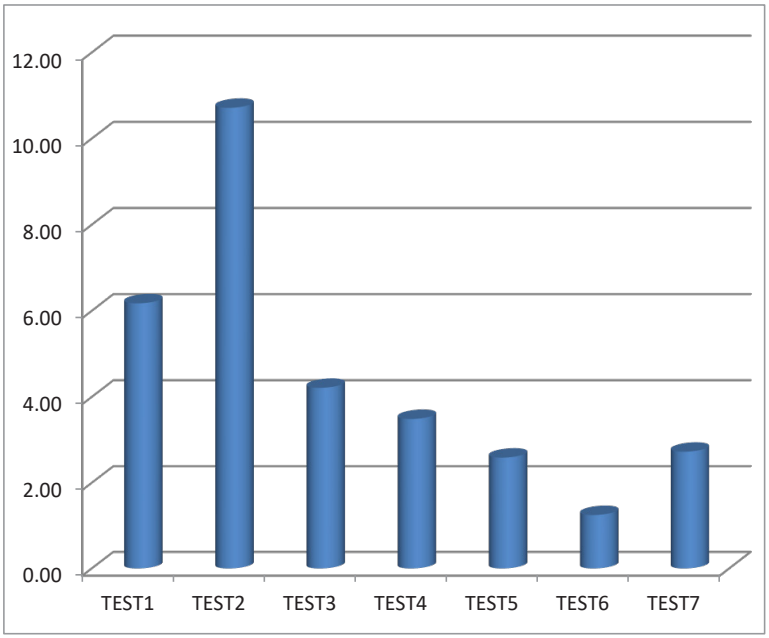

Fig. 2. Growth rate of the Tien Giang University male football team after 8 months of training.

Note: In Figure 2, Test 1: Standing long jump, Test 2: Standing high jump, Test 3: 100-metre run, Test 4: 30-metre sprint from a four-point starting position, Test 5: Cooper test, Test 6: 5x30m sprints, Test 7: 20-metre zig-zag run.

For each test, the specific changes are as follows:

The standing long jump test: The average result before training was 226 cm, and the average result after training was 240 cm, which is 14 cm longer and corresponds to the growth rate W = 6.17%. The growth was statistically significant because $t_{calculated}$ = 10.05 > $t_{standard}$ = 1.706 at the possibility p < 0.05. As a result, the performance of the players in the standing long jump test had made an obvious progress after one year of training.

The standing high jump test: The average result before training was 47 cm, and the average result after training was 52 cm, which is 5 cm higher and corresponds to the growth rate W = 10.72%. The growth was statistically significant because $t_{calculated}$ = 12.14 > $t_{standard}$ = 1.706 at the possibility p < 0.05. As a result, the performance of the players in the standing high jump test had made an obvious progress after one year of training.

The 100-metre run test: The average result before training was 12.62 s, and the average result after training was 12.10 s, which is 0.52 s and corresponds to the growth rate W = 4.21%. The growth was statistically significant because $t_{calculated}$ = 11.58 > $t_{standard}$ = 1.706 at the possibility p < 0.05. As a result, the performance of the players in the 100-metre run test had made an obvious progress after one year of training.

The 30-metre sprint test from a four-point starting position: The average result before training was 3.66 s, and the average result after training was 3.53 s, which is 0.13 s faster and corresponds to the growth rate W = 3.49%. The growth was statistically significant because $t_{calculated}$ = 9.06 > $t_{standard}$ = 1.706 at the possibility p < 0.05. As a result, the performance of the players in the 30-metre sprint test from a four-point starting position made an obvious progress after one year of training.

Cooper test: The average result before training was 2512 m, and the average result after training was 2582 m, which is 70 m longer and corresponds to the growth rate W = 2.59%. The growth was statistically significant because $t_{calculated}$ = 19.45 > $t_{standard}$ = 1.706 at the possibility p < 0.05. As a result, the performance of the players in the Cooper test had made an obvious progress after one year of training.

The 5x30m sprints test: The average result before training was 20.70 s, and the average result after training was 20.40 s, which is 0.3 s faster and corresponds to the growth rate W = 1.25%. The growth was statistically significant because $t_{calculated}$ = 4.53 > $t_{standard}$ = 1.706 at the

possibility $p < 0.05$. As a result, the performance of the players in the 5x30m sprints test had made an obvious progress after one year of training.

The 20-metre zig-zag run test: The average result before training was 4.21 s, and the average result after training was 4.13 s, which is 0.11 s faster and corresponds to the growth rate W = 2.73%. The growth was statistically significant because $t_{calculated} = 6.15 > t_{standard} = 1.706$ at the possibility $p < 0.05$. As a result, the performance of the players in the 20-metre zig-zag run test had made an obvious progress after one year of training.

DISCUSSION

Some related studies (Lee & Joo, 2020; Farley et al., 2020) show that they have started to build a system of exercises regarding the enhancement of physical strength for footballers, along with affirming that these exercises can be used as evidence for coaches and the development of exercises for recovery (Woods et al., 2018). However, this research still has a small number of participants, a shortage of investigation time as well as limited tests, leading to some of the data not being the most effective indicators. Bujnovsky et al. (2019) investigated the speed and agility of 15 year-old footballers by using different tests including linear running sprint for 5 m and 10 m, as well as flying sprint for 20 m. In comparison with the similar test, our tests are more diverse, and thus have a higher validity for using to appraise the ability to sprint and physical strength after training. From these results, we have come to the following conclusions:

1. The system of exercises will be used to develop physical strength for the universities' male football team. The school and the Physical Education department will practice the chosen exercises from the research in the football training programme, implement the fitness tests for Vietnamese universities' male football teams from now on, and concurrently popularise these to become materials for local institutions. 2. Implementing the chosen exercises from the research to improve the physical strength of universities' male football teams. It is essential that these exercises are to be perceived as specialised regarding training for physical strength development in universities' male football teams. 3. More subsequent comprehensive and in-depth research and investigations are needed (regarding other factors of physical strength during sporting events and other aspects such as reflex, psychology, medical biology, etc.). It is an essence for the investigation to be continued on a larger scale of participants and for the data and results to be more reliable, since this investigation was only done on male students of the Tien Giang University male football team.

CONCLUSION

With the test preparation process, the study identified 7 tests to assess football players' physical fitness. After 8 months of training, the physical fitness of the Tien Giang University male football team had made great progress. The best achievement was recorded in the standing high jump test with the growth rate of 10.72%, while the lowest growth rate was 1.25% in the 5x30m sprints test. This shows that the selected exercises had a good impact on physical development of male football players at a college level.

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PRIMIJENJENO ISTRAŽIVANJE VJEŽBI ZA POBOLJŠANJE TJELESNE KONDICIJE SPORTISTA UNIVERZITETSKIH FUDBALSKIH TIMOVA

Fudbal se naziva kraljem sportova zato što je jako atraktivan i prepun iznenađenja. Taj sport je potaknuo mnoge ljude da se njime bave i takmiče za bolje zdravlje i sveobuhvatan razvoj. Na univerzitetima je fudbal od posebnog interesa kao vježba za studente koja poboljšava zdravlje, kreira ugodnu atmosferu i smanjuje stres nakon predavanja. Međutim, fizička snaga zapravo još uvijek predstavlja problem za fudbalere i studente iz Vijetnama. Oni se često iscrpe na kraju takmičenja pa, prema tome, to utiče i na njihov učinak. Ova studija je usmjerena na vježbe za poboljšanje tjelesne kondicije univerzitetskih fudbalskih timova, a doprinosi kvalitetnom poboljšanju treninga i takmičenja te je referenca za napredak fudbalskog treninga na univerzitetskom nivou. Proveli smo testove za procjenu prije i nakon treninga te uporedili rezultate kako bi utvrdili faktore istraživanja, uključujući opću i profesionalnu fizičku snagu. Odabrani testovi su skok u dalj iz mjesta, skok u vis iz mjesta, trčanje na 100 metara, sprint na 30 metara iz niskog starta, Cooperov test, sprint 5x30 metara i cik-cak trčanje na 20 metara. Rezultati studije pokazuju da je nakon 8 mjeseci treninga fizička snaga igrača iznimno poboljšana, a što dokazuje efikasnost odabranih vježbi.

Ključne riječi: fudbal, tjelesna kondicija, učinak

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PHYSICAL ACTIVITY ENGAGEMENT IN LATER LIFE: A PHYSICAL LITERACY PERSPECTIVE

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ABSTRACT

The purpose of this study was to investigate physical activity engagement among elderly people framed by early development of physical literacy. A number of ten participants aged between 70 and 80 years of age were recruited to participate in this study. Open-ended interviews were conducted through individual and group interviews. The interviews were specifically designed to collect data about the embodiment and lived experiences of engaging in physical activity in later life as well as during the course of their life. Data were analysed inductively to develop themes in the data. Theoretical analysis of physical literacy was used to discuss the empirical data analysis. The results showed three patterns in the data, including their participation trajectory, engagement as a learning journey and physical activity experiences manifested as the body ages.

Keywords: physical literacy, physical activity, older adult, embodied experience

INTRODUCTION

More than two decades after the development of the concept, physical literacy (PL) has now mushroomed across the globe. International scholars have adopted PL discourses which are articulated in various contexts, ranging from educational settings to health promotion arenas (Hyndman & Pill, 2017). Canada, among other countries, has systematically recontextualised PL in a variety of sectors with regard to their sporting systems, recreational industries and educational services (Sheehan, Robinson, & Randall, 2019). Despite its massive take-ups, PL remains to be understood with a lack of sophistication, especially among practitioners (e.g., Harvey & Pill, 2019). The critiques have also varied, ranging from addressing issues of the technical operations (e.g., assessments, curriculum development) to criticising underlying assumptions. Jurbala (2015) argued that, at the outset, the concept of PL is very much complex.

In the early years of its conceptual development, PL received little attention and close examination. Whitehead (2001) opened up a scholarly dialogue to elaborate PL, and its theoretical ground had strongly characterised its attributes. In recent conceptualisation, it seems to be more lessening in terms of its philosophical grips. She defines physical literacy as "the motivation, confidence, physical competence, knowledge and understanding to maintain physical activity throughout the life course" (Whitehead, 2010, p. 11). Since then, the definition of PL has developed exponentially (Bailey, 2022), culminating contested conceptualisations instead of converging views. In terms of the ladder abstraction of PL, for example, Young, O'Connor and Alfrey (2019) identified that there were three levels of PL abstraction. The first one is a low level of abstraction referring to the origin of PL concept which includes philosophical underpinnings of PL, such as monism, phenomenology and existentialism. The second level encompasses middle-level abstraction which is a more adoptable concept maintaining "complexity around its intentions, loosening connections to its philosophical roots" (p. 9). Young, O'Connor and Alfrey (2019) also included Whitehead's definition of PL in 2010. Lastly, the high-level abstraction of PL constitutes simplistic definitions in which the core

characteristics and philosophical foundations have been diminished. The current study attempted to incorporate the more complex conceptualisation (lower level of abstraction) in the framework of PL. This included the notion of being literate as an embodiment of the capacities to interact effectively in the actual world we live in (Whitehead, 2017).

While unique lifetime engagement in sport and physical activities (PA) is one of central tenets in PL, furthermore, much more attention has been given to younger populations than the older ones. It is inevitable that research on physical activity among elderly people is abundant, with some conclusive knowledge being achieved. Researchers have also taken advantage of this available information to elaborate the PL framework for studies with older adults. For example, Huang, Sum, Yang, and Yeung (2020) reviewed reports on the measurements of this population regarding their physical competence. Their review resulted in a new understanding on how research in this area has been centralised around the use of self-reported and objective assessment. Another example is the study conducted by Campelo and Katz (2020) describing the participants' perceptions of using technologies when engaging in PA. Despite the fact that there are only small numbers of studies framed by PL theories, much of the focus is further skewed towards the physical competence domain of PL. In other words, literature on older adults' PL seems to be conceptualised in a high level of abstraction terrains reducing much of the philosophical bedrocks of PL. Additionally, a critical inquiry into policies and research practices have informed that many studies of PL have been underpinned by phantasmatic logics alongside the horrifying and beatifying narratives if (not) doing PA (Quennerstead, McCuaig, & Mårdh, 2020). Despite the fact that the settings of their inquiry were in the area of health and physical education, the available literature in PL among elderly remains to have similar logics and narratives.

The current study focused on older adults' engagement in PA which has been framed by the concept of PL, but I specifically referred to the conceptualisation of PL at the lower levels of PL abstraction (Young, O'Connor, & Alfrey, 2019). I also tried to avoid the logical and narrative traps identified by Quennerstead, McCuaig, and Mårdh (2020). Instead, I looked at how elderly individuals experienced their embodiment and the life trajectory of those embodied experiences in connection with the elements of PL. More specifically, the purpose of this study was to investigate physical activity engagement among elderly people framed by early development of physical literacy.

MATHODS

PARTICIPANTS

A number of ten individuals were recruited to participate in this study. I set the recruitment criteria including those whose age range was from 70 to 80 years old and who still maintained engagement in any forms of physical activity (e.g., recreational PA, sport, exercise). The maximum variation was also attempted to include female (N = 4) and male (N = 6) participants. I happened to access the participants through a government agency, personal connections and accidental encounters. Informed consents were sought prior to interviews. I also maintained ethical practices by informally asking for consents.

DATA COLLECTION

Data were collected through in-depth interviews with two interviewing strategies. First, I took advantage of a government programme, inviting physically active individuals from four major cities in Indonesia. I was able to put together seven participants in a group interview in which they shared their PA/sporting experience throughout their lives. The second strategy involved individual interviews with the rest of the participants, collecting the same information as the first strategy. All interviews were recorded using a digital voice recorder and verbatim transcribed for further analysis.

DATA ANALYSIS

The analysis of the collected data was conducted through the interpretative paradigm focusing on looking at latent meanings of the provided information. More specifically, thematic analysis was performed to identify patterns in the data (Braun & Clarke, 2006; Braun, Clarke, Hayfield, & Terry, 2019). Steps in the analysis included familiarisation with the data, inductive coding, theme development, and refining and defining themes. This process began inductively and then moved deductively towards the end of the analytic steps. I also utilised ATLAS.ti 9, a computer-assisted qualitative data analysis to help with the process recommended in the thematic analysis.

RESULTS

The analysis facilitated the development of three major themes in the data. These are the description of participants' PA throughout their life course, the learning journey as they engaged in PA, and their embodied experiences regarding PA as they aged. The following sub-headings presented the three themes.

TRAJECTORY OF PARTICIPATION: PHYSICAL ACTIVITY AND SPORT THROUGHOUT THE LIFE COURSE

Data showed the pattern of their current participation in terms of the types of PA. Although the majority of the participants engaged in non-competitive activities, three older adults in this study engaged in high levels of competition. More specifically, they competed in various events within masters athletics championships, both locally and internationally. For example, Diajeng competed in a race walking event since her mid adulthood.

> "I began to compete in Asian Champs since eighty-one. At that time, I won race walking on every championship, luckily, and in nineteen ninety-five, I went to Japan, to Miasaki to compete in a World Cup. All the word-class champions came to that event. Thank God, I still made the top seven at that time. My competitors were excellent, coming from Germany, the U.S., Italy. After that, I came back, competing in Asia and national competitions. And now, I still engage in 5 k and 10 k race walking." (Diajeng)

Some other participants preferred to engage in recreational activities to stay physically active. At the time of the interviews, their activities included low impact aerobic dance, cycling and archery. A male senior, Bambie, said: "It's not about anything, we're just a cycling community, especially for the elderly." Despite the fact that the analysis has identified these two forms of PA, the competitive and non-competitive divides were not exhaustive. This is especially apparent among those who took multiple roles in their PA. Some of the athletes in this study ran a youth soccer club or coached emerging athletes. Similarly, Harrold, who actually did archery for recreational purposes, worked simultaneously in a national federation that was responsible for high performance programmes in sport climbing.

Another pattern in the data included participation during youth and adulthood. Most of participants (N = 8) have shifted the types of activities as they entered new steps in their lives. Some of them had even changed several times as their living situation also changed. While most of them did not mention changes in their aging physicality, they were more likely to consider that their former PA had no longer been suitable. For example, Daniel had played field hockey since he was in college. He switched to long distance running simply because he no longer needed team mates to do the running. Similarly, Kathy who engaged in various games said: "I took part in masters athletics. I actively participated there, why? After I got old, I wanted to play basketball. But with whom? No one wants to. Am I right? Also, volleyball; nobody at my age wants to play." It may also be noteworthy that some participants did not participate in PA when they were younger. They started to be active in their later lives mainly because their health care provider suggested to be more physically active. There were also two participants who had stayed in a single activity throughout their life span. It was more likely because their activities had become their incomes or something to live in. Examples included Johnny who coached the youth national team and Leigh who was a dance instructor.

One central argument within the physical literacy debate is the importance of early exposure to active living during childhood. All participants in the current study had been exposed to the environment, exposing them to active moving. In the old days, they enjoyed free play, as it was enabled by parenting styles and practices back then. Additionally, schools played important roles in introducing PA and encouraging them to engage in PA, in particular through intramural sport programmes. Diajeng described her experience, "I played sport since I was in elementary school. In middle school, I was a volleyball player. At that time, I engaged in swimming and softball too." These various forms of PA being introduced early in her life had finally provided her with the disposition to enjoy diverse PA in later life. Furthermore, most of their lives had been dominated by manual work in Indonesia during the 1950s. Participants grew up in this environment in which they had no choice but to use much of their physicality. For example, it took almost a half of the day for Sherly to walk to her elementary school. She even biked more distance when attending middle school. For the participants, this manual work had been the condition, exposing them to be physically active. Later in their lives, the experience of doing manual work had become their disposition to engage in PA similar to their former activities, notably walking and cycling.

PHYSICAL ACTIVITY ENGAGEMENT AS A LEARNING JOURNEY

The second theme has been developed around the pattern of information regarding how the participants' PA engagement represented the learning journey. This was possible, since their PA did not always move in a linear fashion. It means that the trajectory of PA had been filled with fragmented moments. In each of these fractures, there were moments of learning. Because the learning element is also central in the concept of PL, the analysis focused on how the participants learned and developed embodied capacities regarding their PA. Despite the fact that they did not state it explicitly, it could be inferred that free play during childhood provided the opportunity for incidental learning. Their interactions in the world of free play facilitated the skill and bio-motor development. Kathy stated: "Since I was

very young, people around me called me tomboy. I climbed trees and played with boys. Soccer, I was the only girl. I also liked to jump around at school. That is probably what made my legs strong." It looked apparent that participants who were competent in various sports and games in their adulthood tended to have free play experience. Motivation to always be physically active could also be anticipated from this early connection with an active start.

As the participants had moved on in their stages of life, one important fragmented moment included giving up their activities and beginning to engage in new ones. At this point, further analysis resulted in an understanding of the roles of school-based programmes. The majority of the participants took advantage of such programmes to learn more specific knowledge of some sports, especially on the competition side of the activities. The participants who excelled in sports tended to stay engaged in competitive PA throughout their lives, even in their late adulthood. However, it is noteworthy that they seemed to compete in competitive environments that had been appropriate to their competencies, capacities and interests. Among all the participants, there was only one who had internationally been an elite athlete. In other words, the analysis showed that appropriately intensive competition could develop motivation to engage in competitive PA, despite their aging bodies.

The fragments within their PA trajectory had also been characterised by switching to new roles. These switches required a learning process. Those who entered formal responsibilities had been demanded by professionalisation pathways in their learning. Leigh had been very active in training and dancing prior to her marriage. When raising her children, she took years of not engaging in dance. At the time, she was ready to get back to dancing; she wanted another role: a dance instructor. She did not only take programmes about the pedagogical dimensions of teaching dance, but also took classes on new dances she never knew before. Another example included the time when Harrold was encouraged to take a coaching role. He went overseas to take his coaching certification in his late 60s. Harrold described, "I'm now an archery coach. I took level one of coaching certification in Korea for twenty-one days." The participants showed some degrees of being literate,

PHYSICAL ACTIVITY IN THE TIME OF AGING BODIES: AN EMBODIED EXPERIENCE

One of central tenets of PL is embodied experience as it is derived from phenomenology. The analysis showed a pattern in the data about how participants experienced PA in and through their embodied dimensions. More specifically, it focused on the pattern of ingrained habits developed over time during their life course. Since there are dimensions in PL being bodily experienced, it included experiences of having physical skills, motivation and knowledge to stay engaged in their PA.

For those who had had prolonged commitment in one type of PA, the embodied experience had centralised around physical skills. An example included Augusto's description of how good his soccer skills were back then. He said: "I'd been a soccer player for Local City United, for ten years. All those years, my record's never been broken. That is, I never sat in the substitute bench. I always played. Also, during all those years, I never got injured, nor made my opponents injured." Data suggested that PA engagement for some extended time could facilitate the embodiment of PL through skill execution.

Another embodied experience was the embodiment process that had enhanced their quality of life. For example, Johny recounted his experience of having privilege to travel internationally because of his action with his embodied dimensions. He told his story:

> "So, on Asian Championship, that's now masters, I won one hundred metre. After being hosted in Singapore, it was then in Brunei, and I won one hundred and two hundred —then I went to Thailand. So, I have been really traveling around the world with my legs. Because these legs can do the job. I won in America." (Johnny)

The above subset of data showed that the experience of traveling abroad was actually the consequence of his sporting embodiment, in particular his legs. The framework of PL might be applicable here to look at his ability to internalise parts of the body as having contributed to his quality of life.

The analysis also showed how the embodied experience connected to motivation. More specifically, participants articulated their activities with motivation embedded in their embodiment. Kathy, for example, competed in a racing event of 100 metres in a local masters athletic championship. She suffered an accident, but she resisted to fight for the podium. She described how she articulated motivation through her embodiment: "I was leading the race with the finish line only two metres in front of me. I fell down. I didn't give it up. I tried hard to go on crawling, then rolling my body over the line. I still got silver." Furthermore, some participants tended to think about the connection of their frailer bodies and the development of health problems as getting close to dying. In his mid 70s, Daniel regularly participated in a marathon, which he completed in about seven hours. When practicing this endurance running, he ran around in a jogging track nearby his house sixty to seventy times. Daniel strategically

kept his motivation up by dedicating his last laps to his acquaintance who already passed away. As the running got tougher, he would talk to himself during each lap; "This lap is for you Greg, my son. This lap is for you dad. This lap is for my mom. This lap is for my teacher. This lap is for you my friends." One philosophical ground of PL is the unity of body and mind. Daniel's experience exemplifies this unification not only through the integrity of his running body and motivational nurturance but also through the harmonisation of spirituality.

DISCUSSION

The results of the current study described physical activity engagement among elderly people. However, the participants' experience has been analysed both inductively, based on the empirical data, and in the theoretical framework of physical literacy. It would surely be too much of a stretch to discuss the analysis of the empirical data with the origin of PL conceptualisation. On the one hand, the empirical data were very much inductive, representing the participants' concrete experiences of doing PA on a day-to-day basis. On the other hand, Whitehead's conceptualisation is firmly grounded in philosophy, notably under the tradition of phenomenology, existentialism and monism (2001, 2007). Therefore, this discussion section is dedicated to elaborate the connection of the empirical data and the theoretical analysis, relying much on interpretive action.

It can be interpreted that the participants demonstrated an attitude derived from PL philosophical attributes. They had some kind of capacity to articulate their embodied potentials to improve the quality of life (Whitehead, 2007). Most of them reflected on their journey through life that their quality of life had been improved in one way or another. Some participants certainly demonstrated what Durden-Myers, Whitehead and Pot (2018) called human flourishment. Despite the diverse forms of PA they engaged in, the participants showed motivation to move not only for the sake of being healthy in their late adulthood, but also for the entry point towards the world (Whitehead, 2001). By being in the world, which is the derivation of phenomenological thoughts, they interacted with the environment through embodied dimensions (Pot, Whitehead, & Durden-Myers, 2018). Moreover, as the analysis focused on life-time engagement, it paid close attention to the notion of disposition. In this sense, the PL framework does not view embodied dimensions as a product or process (Haydn-Davies, 2010). Data clearly showed nuance in which participants' experience has been pre-reflective in nature. This might be developed over a long period of time so that embodied dimensions have become habitual. Those who engaged in sport, for example, demonstrated the habitus of being excellent, specifically the taste for embodied competition (Tidén, Sundblad, & Lundvall, 2021). Further philosophical ground is existentialism through which their engagement in PA in specific settings and contexts could be framed as interaction that forms themselves (Whitehead, 2001). They might also realise that their existence as aging human beings in the world had been attributed by the articulation of their embodied dimensions. Through these embodied dimensions, the participants had also continuously created themselves, since their lived world, including their own embodiment, changed as they aged. In fact, they maintained to be confident with embodied movements despite the appearance of challenging physical environments. With aging bodies, any physical environment could become challenging. Many of the participants had dropped out from their previous PA because their physical conditions did not allow them to continue their engagement. However, they carried over their engagement in different forms of activities that they could still handle with their embodied situation. Embodied learning took place in each of the fractures of their trajectory, and the participants seemed to be eager doing the new PA (Griffin, 2017). In other words, they were literate enough to read the environment to keep up with their embodied movements.

CONCLUSION

Upon its wide acceptance in the community of scholars, policy makers and practitioners, the notion of physical literacy has been differently understood and recontextualised in diverse settings. Some argued that most of PL research and practices have loosened the philosophical grips leading to detachment from the origin of PL conceptualisation. The current study was an attempt to bring back the framework of early PL notion in reading the empirical data regarding physical activity engagement in later life. The pattern in the empirical data, including the trajectory of PA engagement, embodied learning and embodied experience throughout the lifespan, has been linked to the PL philosophical attributes. These are monism, existentialism and phenomenology. Indeed, these are difficult concepts to grasp. Follow-up studies are recommended to elaborate PL within this challenging terrain to afford new knowledge and understanding of PL research and practices alongside its philosophical bedrocks.

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BAVLJENJE FIZIČKOM AKTIVNOŠĆU U STARIJOJ DOBI SA STANOVIŠTA FIZIČKE PISMENOSTI

Svrha ove studije je bila ispitati bavljenje fizičkom aktivnošću kod starijih osoba u okvirima ranog razvoja fizičke pismenosti. Deset učesnika u dobi između 70 i 80 godina starosti je odabrano za učešće u ovoj studiji. Intervjui otvorenog tipa su provedeni posredstvom individualnih i grupnih intervjua. Intervjui su specifično osmišljeni za prikupljanje podataka o očitovanju i proživljenim iskustvima bavljenja fizičkom aktivnošću u starijoj dobi te tokom njihovog života. Korištena je induktivna analiza podataka kako bi se u njima razvile teme. Teorijska analiza fizičke pismenosti je korištena za diskusiju empirijske analize podataka. Rezultati su pokazali tri obrasca u podacima, uključujući putanju njihovog učešća, angažman kao put učenja i iskustva bavljenja fizičkom aktivnošću koja se očituju kako tijelo stari.

Ključne riječi: fizička pismenost, fizička aktivnost, starije odrasle osobe, tjelesno iskustvo

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GOALKEEPER HEIGHT INCREASE IN THE INTERNATIONAL SCENARIO FOR THE LAST 90 YEARS AND AN ANALYSIS OF A SIMULATED GOAL SIZE INCREASE

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ABSTRACT

First, a non-local and elite goalkeeper-specific study on height change over time is presented. This study can be seen as an element and contribution to the discussion on extending the goal posts and crossbar in association football. The internationality and player quality characteristic of the study is based on the analysis of past FIFA World Cup goalkeeping squads, which is the only truly top-level and international tournament for more than 50 years. Second, the study analysed whether the game and its fairness would be enhanced by increasing the chances of scoring as a result of increasing the goal size; this is done through the definition of two measures and the evaluation of the past World Cups, as well. The results are positive; nonetheless, it is discussed that any goal frame change would have to be subjected to more analysis because decreasing too much, the unpredictability of football could be as negative as many matches defined by penalty kicks, or many matches finishing 0-0.

Keywords: goalkeeper height, World Cup, last century, goal size enlargement, game enhancement

INTRODUCTION

FIFA very seriously discussed enlarging the size of the goal 25 years ago (Mortimer, 2012). The goal was to increase goal scoring which has clearly diminished over the last century; in fact, this point returned in last decade (Ingle 2006) when in the 2006 and 2010 World Cups, just 2.30 and 2.27 goals per game were respectively scored (Kubayi & Toriola, 2019). Now, the idea proposed by FIFA back in 1996 (the decade of the Cup with the minimum goals per game, 2.21) was as serious as detailed: increments of 50 and 25 cm in the horizontal and vertical directions, respectively. The proposal was even conveyed to the International Board which also discussed it in its annual 1996 meeting (Homewood, 1996); this body, that determines the laws of the game, did not finally decide any goal frame change because there were more calls against than in favour of this one. In this regard, reasons for and against goal size increase are both well-based as explained next.

There are currently two main reasons in favour of a change; one comes from economics and the other by simple observation of the age of the laws and of human height increase in the last 100 years. Football has become an international, powerful and very rich industry, and it is natural that the football business tries to increase the appeal of the game or to optimise it; that is what industries do. One of the proposed ways to do this is to raise the number of goals per game. A quite recent proof that football is a full business is the April 2021 creation of the European Super League; the study will not discuss whether it was plain greed or just a natural

consequence of the economic downturn, for big clubs, due to the current pandemic; nevertheless, the decision was simply economic optimisation. The second reason is the rules' age in relation to human height increase; the game is being played with laws established 150 years ago; there have been changes, of course, but the fundamental rules, such as the size of the goal, are quite old, whether they are viewed from the biological or the economic point of view. To relate both reasons, we quote Prof. Bell (University of Reading, 2020): "Modern-day football is a global industry worth billions of pounds in revenue, yet it still uses laws on goal sizes drawn up in the mid-19th century. We suspect that footballers' body shapes have changed, with more emphasis on fitness and diet, as well as growth in average height in the general population. But up until now, this has never properly been studied among a representative sample of professional footballers."

On the other hand, two reasons against increasing the goal size have been, first, a popular or global reaction when the idea was discussed, which was in fact the reason for not finally including the proposal in the documents of the International Board meeting in March 1996 (Homewood, 1996). Second, the notion that low scores or the rarity of goals in fact make football an already very exciting game. Indeed, if the goal size is ever increased, this will have to be done in a controlled way because it may backfire precisely in the sense of the game appeal.

One factual, clear and extreme game situation in which both points of view collide are penalty shootouts; these are considered by fans, from both extremes, as the worst and most unfair way to end an important match, to the most exciting and best way to finish this type of games. Interestingly, shootouts are related to low-scoring games because the chances of a draw at the end of a match are larger when the scoring is low. In fact, we have easily computed that if the goals scored are 3 as maximum, the basic probability of a draw result are as high as 40%, whereas if the goals scored are allowed to be up to 5 in the mathematics, the chances of a draw drop to 33%. Now, fairness is a good point when discussing the rightness of penalty shootouts, but we are not going to particularly discuss the fairness of shootouts in deciding the winning team; nevertheless, we do study herein if another reason in favour of extending the goal size could be a mathematical reduction of the number of games that are decided by individual shots from the penalty mark at the end of 90 or 120 minutes of team play.

It is very important that sports are unpredictable, or the results thereof; otherwise, few people would be interested or watch them and this has economic consequences (Szymanski & Késenne, 2004). However, it is also important that games have a high level of fairness, which is not at all that the best ranked team beats the other, but that the chances are high for the team that has played better the extant game in team-play time to win it. Thus, we propose as a third reason in favour of goal size change, an improvement of game fairness, not only by a reduction of games decided by shootouts, but also by considering the teams' performance during the 90 (120) minutes of football. There have been academic papers on improving the fairness of the game through geometry change of the old rectangular goal area (Morales, 2016; Morales, 2018); however, there are no previous research articles on the idea of increasing fairness by means of geometry change of the goal frame.

There are two main objectives in this paper; first, to study the change in the last century in goalkeeper height, and second, to answer the question whether the game and its fairness would be enhanced by increasing the goal size. Both objectives are related, as discussed, or a definite height increase in elite and international netkeepers would justify an increase in goal size, and the justification will be stronger if it can be shown that enhancement and fairness measures (metrics) improve by this rule change. Height increase in the general population all over the world is a fact, not only observable, but scientifically demonstrated (NCD-Risc 2016); however, there are no academic studies on footballers in the last century, let alone goalkeepers. In this study, the height of solely top-level players is analysed, which will facilitate the study because more extended height data of 100 years ago would be hard to retrieve, and more importantly, highly unreliable. The elite-player set will be defined by means of goalkeeping sub-squads, exclusively from the FIFA World Cup, which will additionally, and importantly, guarantee diversity. To answer the question whether an extension of posts and the crossbar would enhance the game and its fairness, a proposal is to consider that all woodwork (frame hits that are not goals) are considered goals, in order to 1) investigate whether this will increase the probability for the team that has had a better performance to win the game, and 2) study whether the number of games that are decided by shootouts will be reduced. Both simulation analyses will also be done in the World Cup scenario, in particular in the decisive or knockout stages.

GOALKEEPER HEIGHT INCREASE IN THE LAST 90 YEARS

Human height increase in the last century is a fact, which is independent of place (country) or gender (NCD-Risc, 2016). Nevertheless, there are no studies on goalkeepers; one reason is that reliable old data is hard to come by. However, there is a good reason to study this particular height increase, as it can serve as solid data in deciding the increment of the

goal entrance area. As put by Sports Economy Prof. Reade: "Making goals bigger to increase the number of goals scored in matches has been a serious suggestion in recent years. Other rules have changed, so it is not inconceivable that this might happen. If governing bodies do want to use changing player sizes as justification, it's important that decisions are based on solid data" (University of Reading, 2020). In other words expressed by Prof. Floud (author on height-weight changes in the last 3 centuries from the University of Cambridge): "World populations are all growing taller, so it must affect sporting ability and sporting rules" (Homewood, 1996).

METHOD

First, the World Cups of 1958 and 2018 (the last one) are selected, which are separated by exactly 60 years. Nonetheless, Sweden 1958 was chosen more from an academic point of view because previous FIFA World Cups did not have a full and fair qualification process in any of the confederations (world regions): previously, there was much disorganisation and many withdrawals in the processes. For example, qualifications for Switzerland 1954 (the just previous tournament) did not include Africa at all, the South American one had only 3 countries (Argentina not included), and there was a qualified team (Europe) that did not play even one match, namely Hungary. On the contrary, for the 1958 Africa was given a chance, there was an almost full CONMEBOL qualification (9 countries), and there was a rule that no country would qualify without playing at least 1 game (FIFA 2010).

Nevertheless, we require an analysis for over a century; thus, the first World Cup is also considered even though it cannot be said that the best squads played, as there was no qualification process at all for the 1930 tournament mainly because there was not much interest in Europe to participate or to travel to Uruguay by ship (FIFA, 2010).

The goalkeeping sub-squads were composed of just 2 players for the 1930 and 1958 World Cups, and by 3 goalkeepers for the 2018 tournament, which is nowadays a min-max condition. For the 1958 and 2018 Cups, the heights of the players with jersey number 1 were considered as they are considered the starting or first-choice goalkeeper, whereas for the first tournament, when there was no numbering, the height of the goalkeeper who started in the first match was the one computed.

RESULTS

As defined by the methodology, the number of heights or sample sizes were 13, 16 and 32 for 1930, 1958 and 2018 (respectively), with a mean value computation. The results, shown in Table 1, indicate that the increase in the first 28-year period was 5.2 cm, while in the next 60 years, the height increase was 7.1 cm, for a total of 12.3 cm, which could be compared to increments in the general population around the world in a very similar period (NCD-Risc, 2016); nonetheless, one of the main conclusions of the more general study (200 countries) is that the increase has been very diverse: from a minimum of 0.5 cm (Marshall Islands) to 16.5 cm (Iran), for males. Now, the important conclusion of our work is that world-cup class goalkeepers have seen their height augmenting by more than 12 cm in the last 90 years.

Table 1: Mean goalkeeper height throughout the 90 years of the World Cup

	1930 (Uruguay)	1958 (Sweden)	2018 (Russia)
Height [cm]	177.1	182.3	189.4

TWO MEASURES OF GAME ENHANCEMENT INCREMENT BY INCREASING GOAL SIZE

Football players' height has risen over the last century as that of the general population; in particular, mean goalkeeper height at world-cup level has risen by 12.3 cm from the first to last tournaments. This is an important step in any justification for extending the length of the posts and crossbar. Nevertheless, it is not enough because an argument is that not necessarily more goal chances and resulting goals would improve the sport. However, if it can be shown that goal size change enhances the game or a measure of its fairness, the idea will have an even more solid base.

METHOD

Two proposals to measure improvement in the sport through goal size change are presented. Both are primarily based on computing all post and crossbar hits (that are not goals) as goals in a particular set of games. This simulation method of considering woodwork as goals in a past games set is one of the very few ways by which we can evaluate what occurs if the goal is enlarged; in fact, it was used by Mira (2005) when showing that, if the posts (bar) are lengthened by a ball diameter + 7 cm, "all current shots-to-post would be goals", in

his elastic collision model of the wood-ball impact.

Second, both methodologies count all crossbar and post hits (hereafter referred to as woodwork or frame hit for simplicity, and because, officially, the bar is not a post) in the 15 knockout-stage matches of the last two World Cups (2014 and 2018) for a set of 30 games analysed. The third-place match is not included because these games were important a century ago when the World Cup originated from the Olympic Games which grant bronze medals, but nowadays, these games are considered basically friendlies (Morales, 2019).

Subsequently, the first proposal computes the number of matches that, being originally defined by one-on-one penalty kicks, would have been defined more fairly during the actual match or 120 minutes of team play if the goal size were larger, or if all woodwork were goals. It is argued that, if the quantity of matches defined from the penalty mark is reduced, even under the limitation of this simulation, it would represent a game enhancement and improvement in sport fairness.

The second metric proposed is more complex for it intends to measure an increase in the probability for the team that has a better performance to win the game. Match statistics have been correlated to final match result or probability of winning (or loosing) (Liu et al., 2015), but to relate game statistics to defining the better team is new and less objective. Nevertheless, in order to investigate whether goal size change would increase fairness in that sense of the better-performance team winning, a preliminary proposal is to consider corners, ball possession, cautions, and fouls (as measured by FIFA) as the main numbers. The first two are positive because these gauge which squad has superior attack and control, and the other two are negative as those measure who has less fair play or in which team body contact is an important part of its play, as compared to ball contact and control. For each game, a result or score by points is obtained according to: 1 point for winning in any of the first two statistics, and 1 point for the team that "looses" in any of the last two negative numbers, for a maximum of 4 points granted. If there is a tie, e.g., 3 yellow cards for each team, that point will be not granted. The official match report by FIFA (2021) is employed for each computation.

RESULTS

All significant results for the last two tournaments (30 matches studied) are given in Table 2. Each game is named by the FIFA country codes with a separating hyphen; the first 8 matches are from Brazil 2014 and the last 6 are from Russia 2018 for 14 decisive-stages games in which woodwork occurred, given in chronological order. There was only one game with more than one wood hit, which was NED-CRC, and this gives our first result: 16 frame hits in 30 matches for a 53% of games with these impact situations. This number can be compared, positively, to a similar published result, that of 61% for the 2001-2002 La Liga season (Mira, 2005). In column 3 we have the results of whether the bar (B) or post (P) was hit, which gives our second result: 50-50% for crossbar and post hits; as far as our literature review went, there are no similar results for comparison. It is interestingly concluded that, although the compound length of the posts is 40% (sharp) of the whole frame, there is more probability of kicking towards the vertical portion than the horizontal one. Column 5 has the score computed as explained in the Method, and column 6 indicates whether the woodwork or the increased goal frame, has gone in the way of the team that had a superior play (✓) or not (×), according to the computed score indicated.

Table 2 : Woodwork in knockout stages of the last 2 World Cups for goal size increase evaluation

Match	Actual score	Hit type	Hitter	Computed score	Enhancement
BRA-CHI	1-1	B	CHI	1-3	✓
NED-MEX	2-1	P	NED	4-0	✓
FRA-NGA	2-0	B	FRA	2-2	
ARG-SUI	1-0	P	SUI	3-1	×
BEL-USA	2-1	B	BEL	1-2	×
ARG-BEL	1-0	B	ARG	3-1	✓
NED-CRC	0-0	P, B, B	NED (3)	3-1	✓✓✓
GER-ARG	1-0	P	GER	2-1	✓
FRA-ARG	4-3	B	FRA	1-3	×
CRO-DEN	1-1	B	DEN	4-0	×
BEL-JPN	3-2	P	BEL	3-1	✓
BRA-BEL	1-2	P	BRA	3-0	✓
RUS-CRO	2-2	P	CRO	1-3	✓
CRO-ENG	2-1	P	CRO	2-2	

Now, the first main results are, of course, related to our first measurement proposal, which is related to the question of whether an increased goal size will reduce the number of decisive matches that are decided by penalty kicks. For the answer, column 2 indicates that there were 4 matches that finished as draws, where also a frame hit occurred. Because there were 8 matches decided by kicks from the penalty mark (as officially named) in the actual two tournaments, it can be concluded that this number could have been reduced by 50% if the woodwork is computed as goals, and of course, if it is considered that any score change after the woodwork instance is not different to the actual and subsequent score change, if any; this mathematical assumption is a limitation of the study. Interestingly, there is uniformity in these results: the 50% reduction is precisely the same in both tournaments, as in each, there were 2 hit situations in 4 matches that finished as draws.

The second proposed metric is evaluated according to its results for the 14 matches in which there were 16 woodwork instances. The squad that has better performance as measured positively by corners and possession, and negatively by cautions and fouls, has a 5/8 probability of being the one that hits the frame in this set of international and elite matches. 63% may not seem a lot, but it is not at all that the probability for hitting wood is 3/8 for the other team, it is actually just 1/4 because the neutral result (empty cell) accounts for 1/8. It would not be totally correct to conclude that increasing the goal size will benefit the fairness of the game, or that the change will reward the team that "has played better"; nonetheless, it can be stated that the chances for the team that has had a lower performance (according to the definition herein) are only 25% for being the one to hit the bar or post when there are such collisions.

DISCUSSION AND CONCLUSION

Professional goalkeeper height increase has been confirmed, internationally. It is shown that the mean stature of goalkeepers of national teams, that participated or qualified to FIFA World Cups, has increased by 12.3 cm from the first to last tournaments (88 years). This result is important in an eventual decision on extending the overall length of the goal frame, which is one of several ideas to enhance the game.

Two measures of sport enhancement by goal size increase have been proposed; the first counts the number of matches that are decided by penalty kicks and that saw a frame hit, relative to the total number of matches finished as draws in a knockout stage. The result is 50% in the last two World Cups; that is, matches defined by penalty kicks could be reduced by half if the goal size is incremented as explained in this simulation study and under its limitations, the main one assuming that any score change after the hit is not different to the ensuing score change in the real match, but precisely, current scarcity of goals is one of the reasons for a goal frame increment. It can be argued that this result is not sufficient to decide the geometric change; in fact, a large portion of the public considers that finishing a match by penalty kicks is fantastic, but a mathematical analysis –giving use to match statistics– was needed; moreover, a significant portion of the fans considers that ending important games that way is quite unfair.

The second measure of game improvement computes the number woodwork instances produced by the team with the best performance, relative to the total number of frame-hit situations; a draw in performance, or a neutral result, was also a possibility, besides the negative one: inferior performance squad hitting the frame. It could be guessed that if the population or set of hit situations is considerable, the positive results will be larger than the negative ones. We have confirmed the hypothesis in the same World Cup scenario (knockout stages of 2 tournaments, 16 woodwork instances): the positive results are 62.5%, the negative ones 25% and the neutral ones 12.5%. It can also be concluded, in case the neutral results are not considered, that the probability for the team that has had a better performance is 71% for being the one to hit woodwork. It will be harder to conclude that increasing the goal size will benefit the fairness of the game or that the change will reward the team that "has played better"; moreover, it can be argued that the match statistics to define the better team were chosen arbitrarily; however, the results will enrich, mathematically, the universal argument whether more goals are good or bad for the beautiful game. Nonetheless, any goal change has to be well-calculated and subjected to more analysis because decreasing the unpredictability of football results too much could be as negative as many matches defined by penalty kicks, or as many matches finishing 0-0.

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POVEĆANJE VISINE GOLMANA NA MEĐUNARODNOM PLANU TOKOM POSLJEDNJIH 90 GODINA I ANALIZA SIMULIRANOG POVEĆANJA VELIČINE GOLA

Najprije je predstavljena specifična studija elitnih golmana, a koja nije lokalne prirode, po pitanju promjena u visini tokom vremena. Ova studija se može posmatrati kao element i doprinos diskusiji o proširivanju stativa i prečke u fudbalu. Međunarodni nivo i kvalitet igrača koji su karakteristični za ovu studiju su zasnovani na analizi grupe golmana prethodnih FIFA Svjetskih prvenstava, a koja predstavljaju jedino uistinu vrhunsko međunarodno prvenstvo tokom više od 50 godina. Nadalje, ova studija analizira da li se igra i njena pravednost mogu povećati povećavanjem prilika za postizanje golova, a koje predstavljaju rezultat povećanja veličine gola. Ovo se postiže putem definicije dvije mjere i procjene prethodnih Svjetskih prvenstava. Rezultati su pozitivni, ali ipak se smatra da bilo koja promjena okvira gola mora biti podvrgnuta daljoj analizi zato što prevelikim smanjivanjem nepredvidivost fudbala može biti negativna poput mnogih utakmica koje karakterišu penali ili mnogih utakmica sa rezultatom 0-0.

Ključne riječi: visina golmana, Svjetsko prvenstvo, proteklo stoljeće, povećanje veličine gola, poboljšanje igre

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CARDIOVASCULAR REHABILITATION THROUGH AEROBIC WALK TRAINING: A CASE STUDY

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ABSTRACT

Although the results of the research on the benefits of physical activity and exercise against cardiovascular disease are congruent, specific recommendations are very diverse. This is especially true when it comes to planning and programming the physical activity of convalescents. Based on a large amount of previous research, the training technology was developed and validation was performed on 398 participants, while in practice, it was used by more than 25000 people from different populations. The aim of this case study is to demonstrate that it is possible and highly beneficial to apply individual training programming in the rehabilitation of coronary patients. The main working hypothesis is that a 4-week training programme will lead to a significant increase in the participant's state of physical fitness. The implementation of the training technology on a participant who had suffered a myocardial infarction will be presented and evaluated, following a period of four weeks. The training was programmed directly via oxygen uptake and realised under the control of a physician, with constant monitoring of heart rate frequency. Continuous walking is used as a basic training tool. The participant improved the results for maximum oxygen uptake by 26.6%, maximum relative oxygen uptake by 16%, speed at which maximum oxygen uptake occurs by 10%, and on the Cooper test by 10%. He started with 42% of genetic capacity in maximum oxygen consumption (VO_2max) and 39% in maximum relative oxygen consumption (VO2rel). After four weeks of training, he reached 53% of VO_2max and 44% of VO_2rel. Throughout this, he maintained a stable state without any visible symptoms of the underlying disease. This kind of training is a powerful incentive for the increase in cardiovascular adaptation, the oxidative capacity of the skeletal muscles, the biogenesis of mitochondria, and other physiological adaptations of the participant.

Keywords: aerobic training, cardiovascular rehabilitation, coronary heart disease, oxygen consumption, energy consumption

INTRODUCTION

Non-communicable diseases, such as cardiovascular diseases that include both coronary heart disease and stroke, are the cause of about 63% of the world's total deaths, and are an important cause of disability [3, 25].

Strong empirical evidence that physical activity and general cardiorespiratory fitness are a major independent protective factor against cardiovascular disease in both men and women is widely known [6, 9, 19, 20, 22, 25, 26]. It is also known that physical activity is one of the best ways for maintaining vitality and health in adulthood [6, 19]. However, the opposite trend - a decline in the level of physical activity with age - can be easily noticed in practice. Therefore, it is of the utmost importance that physicians consistently recommend physical activity

and programmed exercise to their patients, as well as to the general population [18]. Similarly, physical activity is crucial for the rehabilitation of coronary patients [1, 5, 6, 9, 20-22].

Although the results of the research on the benefits of physical activity and exercise are congruent, specific recommendations are very diverse. This is especially true when it comes to planning and programming the physical activity of convalescents. The ranges in the recommendations from the smallest to the highest exercise dosages are quite large [13]. The most common recommendations are general for the whole population [1, 5, 11, 20, 21, 23]. They refer to aerobic continuous or intermittent exercise by walking or running with medium intensity and duration [1, 5, 10, 11, 20, 21, 23]. In addition, aerobic resistance, neuromotor, and flexibility exercise [1, 5, 20, 21] are recommended. Intensity is determined mainly by the heart rate [1, 5, 10, 11, 20, 21]. The duration of one training session ranges from 20 to 60 minutes [1, 5, 10, 11, 20, 21]. The frequency of exercise according to the recommendations ranges from 2 to 5 times a week [1, 5, 11, 20].

Recommendations like these by physical activity experts leave healthcare professionals, as well as laypeople, in doubt as to what amount of work (intensity, duration and frequency) the individual needs to accomplish in order to achieve health benefits [13]. The amount of work needed for women vs. men also remains unclear [13]. Because of this, few low and medium quality cardiovascular rehabilitation programmes are available on the market [20]. Only a general conclusion exists, which states that those who are moderately involved in physical activity have a 20% lower risk of suffering from coronary heart disease and stroke, and those who engage in physical activity more often or with greater intensity have approximately 30% lower risk than less active persons [1, 10-13, 20].

In order to eliminate said inaccuracies, our efforts are moving towards the establishment of training technology that will enable the individual aerobic software programming of walking training based on oxygen consumption in the rehabilitation of coronary patients [12, 14-16]. All sizes in this process are expressed in units of the SI system. They describe cardiorespiratory adaptations, skeletal muscle oxidation capacity, mitochondrial biogenesis, and other physiological adaptations [2, 7, 9] that are particularly important when working with coronary patients. Previous research has validated and simulated the training technology on 398 participants [14-17]. In the past twenty years, this technology was used in programming physical activity of more than 25 000 people, demonstrating a wide range of factors, including age, gender, health quality, and physical status groups [12, 14-17]. Military and Police Academy students, active military and police force, security workers, recreational athletes, sports injury convalescents, professional as well as elite athletes preparing for world championships and Olympic Games, among other groups, comprised the participants in the study. All of them had different goals and reasons for engaging in systematically programmed physical activity, and the final result was always in line with pre-programmed outcomes. Due to the size and diversity of the sample, a validated individual approach and adaptability, as well as previously mentioned recommendations regarding the impact of the physical activity on health, it is assumed that the same technology can be applied in the rehabilitation of cardiovascular patients.

The aim of this case study is to demonstrate that it is possible to apply individual training programming directly through oxygen consumption in the rehabilitation of coronary patients. Continuous walking with the supervision of doctors and other medical staff was used as a basic training tool. The main working hypothesis (H) is that a 4-week training programme will lead to a significant increase in the participant's state of physical fitness. More precisely, after following the training programme, the participant will have significantly higher values of maximum oxygen uptake (H1), maximum relative oxygen uptake (H2), speed at which maximum oxygen uptake occurs (H3), and the result of the Cooper test (H4) than at the beginning of the study. In addition, at the end of the training programme, the participant will be significantly closer to his genetic capacity in maximum oxygen consumption (H5) and in maximum relative oxygen consumption (H6).

MATERIALS AND METHODS

PARTICIPANTS

The implementation of the training technology was presented in the case study on a sample of one participant who survived a myocardial infarction and was involved in an outpatient cardiac rehabilitation programme. He is 67 years old, with a height (BH) of 171 cm, body weight (BW) of 86 kg, and with a body mass index (BMI) of 29.4. His resting heart rate frequency was 70 beats per minute, the resting systolic pressure was 120 mmHg, and the resting diastolic pressure was 70 mmHg. The participant gave his informed consent to the procedures of the study. The conditions of the study were approved by the university's ethics committee.

STUDY DESIGN

The aim of this case study is to show that it is possible to apply individual training programming directly through oxygen consumption in the rehabilitation of coronary patients. As a basic training tool, continuous

walking under the supervision of doctors and other medical staff was used. For this purpose, a new approach to this problem is presented. This approach, which was validated in the training programming of a wide variety of exercise populations, enables individual aerobic software programming of walking training based on oxygen consumption (Table 1 and 2). Software support was provided by a certified hardware-software system (VAC Bioengineering, Belgrade).

Table 1. First week of aerobic training

Day	Date (mmddyy)	Distance (m)	Time (min)	Oxygen (litre)	Energy (kcal)
Monday	01.03. 21	2183	20	30.60	153.00
Tuesday	02.03. 21	1798	20	24.20	121.00
Wednesday	03.03. 21	2054	20	28.80	144.00
Thursday	04.03. 21	Pause			
Friday	05.03. 21	2157	20	30.24	151.20
Saturday	06.03. 21	1926	20	27.00	135.00
Sunday	07.03. 21	Pause			
	SUM	10118	100	140.84	704.20

Legend: training days, distance crossed for each day, walking time, oxygen consumed at crossed distance, and energy consumed at crossed distance. An example of hardware and software system functioning -VAC Bioengineering

The programming of aerobic training effects and changes was based on the actual health and physical condition of the monitored respondent. The training was programmed every month [14-17]. The training sessions were carried out on a treadmill for the duration of four weeks, and taking place on Monday, Tuesday, Wednesday, Friday, and Saturday mornings. Thursday and Sunday were rest days. One session of walking lasted 20 minutes with a pre-programmed load. Prior to aerobic training, the participant warmed up for 5 minutes, and after the training, he cooled down by walking slowly for 10 minutes. The load was defined by the distance covered and the amount of oxygen and energy consumed. The method for determining the load is given in the exercise protocol.

Calculations of the maximum oxygen consumption, as well as health benefits, such as increasing the maximum oxygen consumption, relative oxygen consumption, the speed at which the maximum oxygen is consumed, and the crossed distance in the Cooper test, are performed according to the mathematical functions described in the experimental procedures. Based on the calculated results, it is possible to evaluate how the programmed training load affects health benefits.

Table 2. Fourth week of aerobic training

Day	Date (mmddyy)	Distance (m)	Time (min)	Oxygen (litre)	Energy (kcal)
Monday	22.03.21	2054	20	28.80	144.00
Tuesday	23.03.21	1926	20	27.00	135.00
Wednesday	24.03.21	2568	20	36.00	180.00
Thursday	25.03.21	Pause			
Friday	26.03.21	1926	20	27.00	135.00
Saturday	27.03.21	2054	20	28.80	144.00
Sunday	28.03. 21	Pause			
	SUM	10528	100	147.60	738.00

Legend: training days, distance crossed for each day, walking time, oxygen consumed at crossed distance, and energy consumed at crossed distance. An example of hardware and software system functioning -VAC Bioengineering

EXPERIMENTAL PROCEDURES

The following describes the procedures based on which the training effects and changes were individually measured, programmed and controlled. For this purpose, the age of the participant was used, and his body height and body weight measurements were taken, as were his results on the Cooper 12-minute running test. Based on these data, we calculated the aerobic indicators in the following manner [1, 14-17]:

Maximum relative oxygen uptake was calculated according to the following equation:

$VO_2rel = 3.134304 \cdot 10^{-7} \cdot K^2 + 0.02077344 \cdot K - 9.03125$

where VO_2rel – is the maximum relative oxygen uptake expressed in millimetres per kilogramme of body weight in one minute (ml . kg^{-1}. min^{-1}), and K – is the value of the Cooper 12-minute running test expressed in metres (m).

Maximum oxygen uptake is calculated according to the following equation:

$VO_2max = [(3.134304 \cdot 10^{-7} \cdot K^2 + 0.02077344 \cdot K - 9.03125) \cdot BW] \cdot 1000^{-1}$

where VO_2max – is the maximum oxygen uptake expressed in litres per minute (L . min^{-1}), K – is the value of the Cooper 12-minute running test expressed in metres (m), and BW – is the body weight expressed in kilogrammes (kg).

The running speed for which maximum oxygen uptake occurs is calculated according to the following equation:

$vVO_2max = 0.0014 \cdot K + 0.1786$

where vVO_2max – is the running speed for which VO_2max occurs expressed in metres per second (ms^{-1}), and K – is the value of the Cooper 12-minute running test expressed in metres (m).

The value of the genetic capacity in relative oxygen uptake is calculated according to the following equation:

$VO_2rel_{(GK)} = VO_2rel_{(I)} + 105 \cdot e[(-.02803419 - .00040123 \cdot AGE) \cdot VO2rel(I) + 0.0000003134304 \cdot AGE]$

where $VO_2rel_{(GK)}$ – is the genetic value of maximum oxygen uptake expressed in millimetres per kilogramme of weight in one minute (ml . kg^{-1}. min^{-1}), $VO2rel_{(I)}$ - is the initial value of maximum oxygen uptake expressed in millimetres per kilogramme of body weight in one minute (ml . kg^{-1}. min^{-1}), and AGE – is age [4, 14-17].

The value of the genetic capacity for the Cooper 12-minute running test is calculated according to the following equation:

$K_{(GK)} = \{VO_2rel_{(I)} + 105 \cdot e[(-.02803419 - .00040123 \cdot AGE) \cdot VO2rel(I)) + 0.0000003134304 \cdot AGE] + 9.1976\}.0.027^{-1}$

where $K_{(GK)}$ – is the genetic value of the distance crossed in 12 minutes during the Cooper test expressed in metres (m), $VO_2rel_{(I)}$ - is the initial value of the maximum relative oxygen uptake expressed in millimetres per kilogramme of weight per minute ($ml \cdot kg^{-1} \cdot min^{-1}$), and AGE – is age [13-16].
The value of the genetic capacity in the maximum oxygen uptake is calculated according to the following equation:
$VO_2max_{(GK)}$ = {VO2rel $_{(I)}$ + 105 . e[(-.02803419 - .00040123 . AGE) . VO_2rel (I)) + 0.0000003134304. AGE] . BW} .1000-1
where $VO_2max_{(GK)}$ – is the maximum oxygen uptake expressed in litres per minute ($L \cdot min^{-1}$), VO_2rel (I) - is the initial value of the maximum relative oxygen uptake expressed in millilitres per kilogramme of body weight per minute ($ml \cdot kg^{-1} \cdot min^{-1}$), AGE – is age, and BW – is body weight expressed in kilogrammes (kg) [4, 14-17].
Next, we determined the amount of oxygen that the participant will consume during one month of training (one of the goals of training) in accordance with the training effects, changes, and capacities, according to the following equation [14-17]:
VO_2 = - 2.6733 $(Week)^3$ + 15.16 $(Week)^2$ + 145.6
$R^2 = 1$
where VO_2 – is the overall oxygen uptake expressed in litres per minute ($L \cdot min.^{1}$), and Week – is the number of weeks of treatment.

EXERCISE PROTOCOL

Once the amount of oxygen which will be consumed during one month is determined, then - in accordance with the set goals, the expected effects and changes - the amount of oxygen is distributed for an individual training session during the week (Table 1 and 2). The aerobic training is designed so that, during each week for the duration of one month, in the first week, we reach one peak (95% VO_2max), in the second, we reach two peaks (96% VO_2max), in the third, we reach three peaks (98% VO_2max), and in the fourth, we reach one peak again (100% VO_2max) [2-17]. Oxygen uptake on the other days ranges from 70% to 100% VO_2max [14-17]. Each aerobic training session lasted for a period of 20 minutes. When the oxygen uptake for each day of the week is determined, the walking speed on a treadmill is also determined for each training session (Table 1 and 2). The speed should enable oxygen uptake, which is prescribed for a particular day of training [13-16]. Multiplying the speed by 20 minutes gives us the distance covered on the treadmill for each training session, and multiplying the oxygen uptake by five, we also get the energy consumption (Table 1 and 2). For the safety of the participant in the training session, heart rate frequency was constantly monitored by a physician. The aerobic training is repeated one month after the testing procedure and programming [14-17].

SAFETY PROCEDURE

Before engaging in the study, the participant passed an examination led by a cardiologist and sports medicine specialist who allowed engaging in moderate physical activity. During the study, blood pressure was monitored on a daily basis, and heart rate functions were monitored by ECG examinations on a weekly basis. During physical activity, heart pulse was monitored as well.

DATA ANALYSIS

The study defines the rules (functions) of the changes in VO_2max, VO_2rel, vVO_2max, the amount of consumed energy (kcal), and the distance covered on the Cooper test (K) over time expressed in months. The functions were determined using the least squares fitting technique. They are described using a logarithm function of the following form:

$Y = a_0 + a_1 \ln (X)$
where ln – is the natural logarithm; X – is the time expressed in months; a_0 and a_1 - are the coefficients of the logarithm function.

RESULTS

All of the results achieved by the participant over a period of 4 weeks of aerobic training are shown in tables 3 to 5 (Tables 3, 4, 5).

Table 3 shows the variables from the Cooper 12-minute running test, maximum oxygen uptake, maximum relative oxygen uptake, and running speed for which the maximum oxygen uptake occurs.

Table 3. Initial and transitive aerobic indicators

$K_{(I)}$	$K_{(T)}$	$VO_2max_{(I)}$	$VO_2max_{(T)}$	$VO_2rel_{(I)}$	$VO_2rel_{(T)}$	$vVO_2max_{(I)}$	$vVO_2max_{(T)}$
1400	1550	1.8	2.28	21.2	24.4	2.14	2.35

Legend: K(I) and K(T) – the initial and transitive values of the Cooper 12-minute running test, VO_2max (I) and VO_2max (T) – the initial and transitive value of maximum oxygen uptake, VO_2rel (I) and VO_2rel (T) – the initial and transitive value of the maximum relative oxygen uptake, vVO_2max (I) and vVO_2max (T) – the initial and transitive value of the speed for which maximum oxygen uptake occurs VO_2max.

Table 4 shows the variables of the total crossed distance for 4 weeks of training expressed in metres, the overall consumed energy over the 4 four weeks of training expressed in kilocalories, the overall VO_2 uptake during walking over a period of 4 weeks expressed in expended litres per minute ($L \cdot min^{-1}$), then the value of the genetic capacity for the Cooper 12-minute running test expressed in metres (m), the value of the genetic capacity of the maximum oxygen uptake expressed in litres per minute ($L \cdot min^{-1}$), the value of the genetic capacity in maximum relative oxygen uptake expressed in millilitres per kilogramme of body mass per minute ($ml.kg^{-1}.min^{-1}$), and the value of the genetic capacity in the speed for which maximum oxygen uptake occurs expressed in metres (m).

Table 4. Overall crossed distance, amount of consumed calories, expended oxygen, and genetic capacities

∑ DT	∑ kcal	∑ VO_2	$K_{(GK)}$	$VO_2max_{(GK)}$	$VO_2rel_{(GK)}$	$vVO_2max_{(GK)}$
42681	2982.2	596.44	2983	4.3	55.5	4.3

Legend: ∑ DT – overall crossed distance for 4 weeks of training expressed in metres (m), ∑ kcal – overall consumed energy for 4 weeks of training, ∑ VO_2 – overall expended VO_2 while walking for 4 weeks expressed in litres per minute ($L \cdot min^{-1}$), K(GK) – the value of the genetic capacity of the Cooper 12-minute running test expressed in metres (m), VO_2max (GK) – the value of the genetic capacity in maximum oxygen uptake expressed in litres per minute ($L \cdot min^{-1}$), VO_2rel (GK) – the value of the genetic capacity in maximum relative oxygen uptake expressed in millilitres per kilogramme of body weight per minute ($ml.kg^{-11}.min^{-1}$), vVO_2max (GK) – the value of genetic capacity of the speed for which maximum oxygen uptake occurs expressed in metres (m).

Table 5 defines the models of change: the model of change for the maximum oxygen uptake over time, the model of change for the maximum relative oxygen uptake over time, the model of change for the speed for which VO_2max occurs over time, the model of change for energy consumption over time, and the model of change in the distance crossed on the Cooper test over time.

Table 5. Models of change

Models	a_0	a_1
VO_2max ($L \cdot min^{-1}$)	1.8	0.6925
VO_2rel ($ml.kg^{-1}.min^{-1}$)	21.2	4.6166
vVO2max ($m.s^{-1}$)	2.14	0.303
kcal	140.84	394.425
K (m)	1400.0	657.29

Legend: VO_2max – model of change of maximum oxygen uptake over time, VO_2rel – model of change of maximum relative oxygen uptake over time, vVO_2max – model of change in the speed for which maximum oxygen uptake occurs VO_2max over time, kcal – model of change of energy consumption over time, K (m) – model of change in the crossed distance on the Cooper test over time.

DISCUSSION AND CONCLUSION

Physical activity "dose" reflects a combination of the duration, intensity or frequency of activity [1, 5, 10, 11, 13, 20, 21, 24]. Thus, defining the amount of physical activity required for health benefits could refer to one or all of these components [1, 5, 10, 11, 13, 20, 21, 24]. The 2014 CDC/ACSM's physical activity recommendations for cardiovascular disease prescribed aerobic exercise: frequency 3–5 d wk-1, intensity 75-85% HRmax, or 60-70% HRR, or 60–70% VO_2max, or RPE 12–13 (scale 6-20), or 4-6 (scale 1-10) for 20 to 60 minutes. Based on these recommendations, it is not possible to determine the right dose of exercise at the individual level. In addition, it is not possible to unequivocally determine the effects and changes of exercise due to the variety of instruments used to quantify physical activity [1, 5, 10, 11, 13, 20, 21, 24]. We have tried to find solutions to these problems in cardiovascular rehabilitation through the application of the training technology we have already developed [14-17]. In this approach, training is individually programmed using the certified software system "VAC Bioengineering" [14-17]. The exercise dose is determined for each individual by frequency, intensity, duration, and type of exercise. Its frequency is 5 d wk-1. Aerobic training is at an intensity of 70% to 100% VO_2max, which is slightly higher than that recommended [1]. The daily training duration is 20 minutes. The training session duration is adjusted to the higher recommended intensity [1, 5, 10, 11, 13, 20, 21, 24]. The type of exercise is continuous walking. The effects and changes in this type of training are monitored through VO_2max, relative oxygen consumption VO_2rel, K, and vVO_2max (Table 3) [12, 14-17]. The training process itself is described by the total crossed distance (∑DT), total oxygen consumption ($\sum VO_2$) and total energy consumption (∑ kcal) (Table 4) [13-16]. In addition, the genetic capacities in maximal and relative oxygen consumption, Cooper's test, and the speed for which maximum oxygen uptake occurs (Table 4) are estimated, as is the percentage of exercise-influenced genetic capacities [14-17]. The recommendations [1, 5, 10, 11, 13, 20, 21, 24] for assessing the realised health benefits, i.e., the effects of training, use different methods, which raises additional concerns. The cardiac rehabilitation programme that we recommend for every practitioner is given. The right amount of exercise that brings him health benefits will be seen from the analyses that follows.

Based on the body mass index, the participant belongs to the category of obese individuals with an increased risk of cardiovascular morbidity and mortality [8]. In the function of a change in lifestyle, he should work on reducing his body weight, which this training enables him to do. The participant, by following the proposed exercise protocol, achieved the following results (Tables 3, 4, 5). During the course of one month (Table 3), he made progress in VO_2max by 26.6 %, VO_2rel by 16%, vVO_2max by 10%, and K by 10% [2, 7, 12-16]. When he began the training (Tables 3 and 4), he was at 42% of his genetic capacity in VO_2max and at 39% in VO_2rel, while after the 4-week training, he reached 53% of VO_2max or 44% of VO_2rel [1, 7, 14-17]. In order to achieve those results (Tables 3 and 4), the participant had to expend, during the course of his 4-week training, 596.44 litres of oxygen ($\sum VO_2$), to cross a distance (∑ DT) of 42681 m and consume 2982.2 kilocalories (∑ kcal) [1, 7, 14-17]. The smallest amount of aerobic power (Tables 1 and 2), which he used to walk for a period of four weeks, had a value of 1.26 expended litres of oxygen per minute ($L \cdot min^{-1}$), that is, 6.3 consumed kcal, while the greatest aerobic power had a value of 1.8 expended litres of oxygen per minute ($L \cdot min^{-1}$), that is, 9.0 consumed kcal. He consumed an average of 8.5 kilocalories per kilogramme of weight per week.

The training was designed (Table 4) for a VO_2max (GK) of 4.3 $L \cdot min^{-1}$, that is, VO_2rel ($_{GK}$) of 55.5 $ml.kg^{-1}.min^{-1}$. Maximum oxygen uptake was achieved at a genetically projected speed vVO_2max ($_{GK}$) of 4.3 $m \cdot s^{-1}$ [14-17].

The models of change (Table 5) have a high level of description of the studied occurrences, significant at the .001 level, and their aim is to quantify the training goals over time. The model of change for VO_2max has a power of $R^2 = 1$, significant at the .001 level. The model of change of VO_2rel has a power of $R^2 = 1$, significant at the .001 level. The model of change for the vVO_2max has a power of $R^2 = 1$, significant at the .001 level. The model of change for energy consumption (kcal) has a power of $R^2 = 1$, significant at the .001 level. The model of change for the K has a power of $R^2 = 1$, significant at the .001 level.

Since following a 4-week training programme, the participant arrived at 53% of VO_2max, that is, 44% of VO_2rel, while following the prescribed training. With new measurements taken each month, he could reach his capacity values in another 8 months [4, 14-17]. The vVO_2max ($_{GK}$) is at 50% of what was genetically programmed, which means that, with the appropriate training, he could improve a further 50% [4, 14-17]. The obtained results (Tables 3, 4, 5) indicate that this kind of training is a powerful incentive for the increase in cardiovascular adaptation, the oxidative capacity of the skeletal muscles, the biogenesis of mitochondria, and other physiological adaptations of the participant [1, 7, 9]. The weekly distribution of load contributes to such a response in the human body (14-17). During the course of one week (Tables 1 and 2), 40% of the overall training is at an intensity of 84% to 100% VO_2max, 20% of the overall training is at an intensity of 80 % VO_2max, another 20% at an intensity of 75%, and another 20% of the overall training is at an intensity of 70% VO_2max [14-17]. Training with such

loads always lasted 20 minutes. The obtained results indicate that individual programming is possible, as is the control of the aerobic training directly through oxygen uptake. During a 4-week aerobic training, the participant improved his results for VO_2max by 26.6%, VO_2rel by 16%, vVO_2max by 10% and his results on the Cooper test (K) by 10%. He started out with 42 % of his genetic capacity in VO_2max, and 39% in VO_2rel, while after 4 weeks of aerobic training he reached 53% of VO_2max, that is, 44% of VO_2rel. The implemented type of training requires an additional eight months to reach genetic capacity. In order to achieve these results, the participant expended 596.44 litres of oxygen (∑VO_2), crossed a distance (∑ DT) of 42681 m, and consumed 2982.2 kilocalories (∑ kcal), and was always in a stable state without any visible symptoms of his underlying condition. Based on these results, all 6 working hypothesis are accepted, which lead to the acceptance of the main working hypothesis that a 4-week training programme will lead to a significant increase in the participant's state of physical fitness.

Programming aerobic training in such a manner provides exceptionally high progress with relatively low energy consumption, a stable state and without visible symptoms of the patient's underlying condition.

Training which includes walking as an "indoor" or "outdoor" physical activity contributes to the improvement of the overall state of health, or even improvement in certain coronary conditions. The obtained results indicate that this kind of training is a powerful incentive for the increase in cardiovascular adaptation, the oxidative capacity of the skeletal muscles, the biogenesis of mitochondria, and other physiological adaptations of the participant.

Given that the results of this case study showed extremely positive training effects and changes, it would be useful to repeat this study on a large number of coronary patients to see if the technology used would lead to similar improvements. The results of this study prove that such an experimental design, while all safety procedures followed, would be safe for the participants.

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KARDIOVASKULARNA REHABILITACIJA KROZ AEROBNI TRENING U VIDU ŠETNJE: STUDIJA SLUČAJA

Iako su rezultati istraživanja o koristima fizičke aktivnosti i vježbe za kardiovaskularne bolesti podudarni, posebne preporuke se iznimno razlikuju. Ovo se posebno odnosi na planiranje i programiranje fizičke aktivnosti rekonvalescenata. Na osnovu velikog broja prethodnih istraživanja razvijena je tehnologija treninga, a provjera je izvršena na 398 učesnika, dok je u praksi korištena na više od 25000 osoba iz različitih populacija. Cilj ove studije slučaja je pokazati da je moguće i iznimno korisno primjenjivati individualne programe treninga u rehabilitaciji srčanih bolesnika. Glavna radna hipoteza jeste da će četverosedmični program treninga voditi ka značajnom poboljšanju stanja tjelesne kondicije učesnika. Implementacija tehnologije treninga na učesniku koji je imao infarkt miokarda će biti predstavljena i procijenjena, a nakon perioda od četiri sedmice. Trening je programiran direktno putem potrošnje kisika i realizovan uz kontrolu ljekara sa neprekidnim praćenjem srčane frekvencije. Neprekidno hodanje je korišteno kao osnovno trenažno sredstvo. Učesnik je poboljšao rezultate maksimalne potrošnje kisika za 26,6%, maksimalne relativne potrošnje kisika za 16%, brzine potrošnje kisika za 10%, kao i Cooper testa za 10%. On je započeo sa 42% genetičkog kapaciteta maksimalne potrošnje kisika (VO_2max) i 39% maksimalne relativne potrošnje kisika (VO_2rel). Nakon četiri sedmice treninga, on je dostigao 53% VO_2max i 44% VO_2rel. Za to vrijeme je zadržao stabilno stanje bez vidljivih simptoma osnovne bolesti. Ova vrsta treninga predstavlja snažan poticaj za poboljšanje kardiovaskularne adaptacije, oksidativnog kapaciteta skeletnih mišića, biogeneze mitohondrija i drugih fizioloških adaptacija učesnika.

Ključne riječi: aerobni trening, kardiovaskularna rehabilitacija, koronarna srčana oboljenja, potrošnja kisika, potrošnja energije

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PHYSICAL THERAPISTS' WORK-RELATED INJURY AND FATIGUE DUE TO BAD POSITION

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ABSTRACT

Purpose: The aim of this study was to investigate the specific risk factors, including postural habits, of WRMDs among physical therapists in Jordan. Method: The study was a cross-sectional, observational study. Results: 14-10.3% reported that lack of commitment to the right body positions is due to the lack of knowledge, while 89.7% thought that it is because of their ignorance of the right positions. 84.6% of therapists reported that they usually experience pain during the sessions, while 15.3% reported that they don't. Conclusion: We found that the pain is caused by many factors; so, it is multifactorial. Some of the factors (life style, working hours, psychological side, etc.) affect their intensity of pain alongside their wrong positions.

Keywords: physical therapist, injury, fatigue, bad position

INTRODUCTION

Work-related musculoskeletal disorders (WRMDs) are simply defined as injuries due to occupational events[1, 2]. The healthcare professionals are vulnerable to sustaining WRMDs during their work routine, which may have a great impact on their life and may cause loss of working days, career shift or even death[2, 3]. However, many studies found a high correlation between WRMDs and activities involving patient contact as well as other factors in the healthcare environment, which is very common in the physical therapy field [4-6].

WRMDs are a complex issue and many factors may contribute to the occurrence of WRMDs, especially in the physical therapy field[1]. Several studies investigated the risk factors that may contribute to WRMDs among physical therapists, which were categorised into physical activities-related factors such as work environment, working hours, physical therapists' habits during exercise, postures, and movements[7]. Another category is related to personal factors such as age, sex, years of experience, and psychosocial issues [1, 2, 5]. On the other hand, many studies categorised the risk factors for WRMDs in the physical therapy field based on postural and habitual factors, such as repetitive movements and bending, as well as lifting-dependent patients, which are considered one of the most important factors in WRMDs in the physical therapy field [6, 8, 9].

Many studies found that most physical therapists have WRMDs within the first 5 years of the work and before the age of 30, which suggests that most of physical therapists have lacked enough experience in using the correct posture and ergonomic position during treatment sessions[6, 10]. Using incorrect ergonomic and postural mechanisms during physical therapy sessions has a significant impact on the physical therapist's health and may lead to an increase in the risk of WRMDs[6]. Kennedy et al. (2010) found that postural adjustment in workstations has a significant effect in preventing and reducing the upper extremity musculoskeletal injuries at work[11]. Another systematic review conduct by Tompa et al. (2010) concluded that using correct posture and utilising good ergonomic training in the work area could lead to a decrease in the WRMDs, in addition to them being cost effective[12].

Identifying and addressing the risk of WRMDs is considered one of the priorities worldwide[13], and it addresses one of the major problems many countries around the world face[3]. However, to date, there is insufficient evidence regarding the effect of postural habits on WRMDs among physical therapists in Jordan. Therefore, the purpose of this study was to investigate the specific risk factors, including postural habits, of WRMDs among physical therapists in Jordan.

METHODS

DESIGN

The study was a cross-sectional, observational study.

SURVEY DEVELOPMENT

We developed a survey that addressed demographic data of the participants, gender, age, place of work, number of patients and reviewers per day, as well as years of experience, in its first part. In the second part of the survey, the questions focused on the nature of PT sessions frequently practiced by the participants and whether they affect their body mechanics, pain and fatigue according to the participants' point of view. After piloting and reviewing by experts, the survey was modified and adjusted for time and ease of completion. A web-based online survey (Google Forms) was used to create the final survey. The survey was distributed through social media applications. A message that contained a hyperlink to the survey was posted to social media groups of physical therapists working in Jordan. The hyperlink directs the participant to the survey which, on its first page, contains a cover letter explaining the purpose of the study and a consent form for participating in the study.

INCLUSION AND EXCLUSION CRITERIA

We targeted PTs working in Jordan. Employed PTs (including self-employed) and PT trainees were eligible to participate in the study and complete the survey. Exclusion criteria included PTs working outside the Hashemite Kingdom of Jordan, pregnant PTs or PTs with musculoskeletal or neuromuscular disorders that occurred before starting their career in physical therapy. Incomplete surveys were also excluded from analysis.

RESULTS

It was found that 69.2% of the sample was working at the private sector, 25.6% at the governmental sector, and 5.1% at the military sector.

The average of working days for the private sector workers was 4-7 days per week, while for the governmental sector, it was 4-5 days per week.

From the whole sample, only 15.4% reported that they do exercises regularly, while 84.6% reported that they don't. Therapists who were careful in applying the right positions during their sessions comprised 33.3%, 25.7% ignored the right positions, and 59% of the therapists mentioned that they were only sometimes careful with regard to their positions. 46.2% of therapists were working at well-equipped clinics, while 53.8% were working at improperly equipped clinics.

56.4% of therapists were working with a load that was appropriate for their capabilities, while 43.5% worked with a load that exceeds their capabilities. 75% of therapist agreed that there are some cases that require more effort and lead to higher intensity of pain and fatigue, which are fractures, paediatrics, and CVAs.

76.9% of therapists supposed that physical therapy profession could lead to pain more than any other job, while 23.1% supposed that it causes pain like any other job. The sample included 74.4% of employees and 25.6% of trainees.

30.8% of therapists reported that their institutions were careful to increase their awareness of the right positions, while 69.2% didn't receive any directions from their working place. 87.2% of therapists though that the pain that they experienced was due to bad positions, while 12.8% thought that the cause of pain was due to other causes, and not due to bad position. 94.9% of therapists agreed that it is important to add a subject at the university that improves their skills and awareness of the right body positions, while 5.1% were not interested. 14-10.3% reported that lack of commitment to the right body positions is due to the lack of knowledge, while 89.7% thought that it is because of their ignorance of the right positions. 84.6% of therapists reported that they usually experience pain during the sessions, while 15.3% reported that they don't.

DISCUSSION

The main finding of this study was that Jordanian physical therapists are also at a high risk for WRMDs. Most respondents in this study were from the private physical therapy sector, and they work more days during the week, compared to other respondents from the governmental and military sectors. Most of our respondents are considered physically inactive, where only 15.4% of all respondents reported that they do exercises regularly, while 84.6% reported that they are not exercising at all. Our findings revealed that most therapists usually do not pay attention to the right posture during sessions, and they usually experience pain. These findings suggest that Jordanian physical therapists have a great risk for WRMDs, and this could be attributed to different reasons like ignorance of the correct posture, with

89.7% of respondents reporting that they usually ignore the right body positions.

The study data revealed that most of the therapists usually have more pain and fatigue during sessions for patients who need lifting, bending, gait assistance, and weight bearing - more than any other patient - given that most of our respondents reported that they are working improperly equipped clinics which lack the needed equipment to handle with these cases. Our findings are in the same line with previous studies, where Al-Eisa et al. (2012) [1] found that Egyptian and Saudi physical therapists were injured while engaging in lifting and bending activities. Furthermore, our data agree with the aforementioned study, i.e., that WRMD prevalence can be variable due the variation in institutions' equipment, knowledge about proper body biomechanics, the care provided by institutions, and the clinical skills.

Approximately two-thirds of our respondents reported that the physical therapy job could cause more pain than another job. However, more than 50% of our respondents reported that their workload matches their capabilities.

About 95% of our respondents reported that the curriculum of physical therapy at the university should have courses address the WRMD and the strategies to minimise or manage it. Here, we should highlight the importance of the strategies that should be employed by physical therapists and their institutions to minimise WRMD. These strategies can vary from self-protection strategies such as using proper biomechanics in lifting and manual techniques. In addition, the institutions should play an important role by providing the needed equipment, and not overloading the physical therapists and trainees, and by providing enough training in lifting skills and by increasing the awareness about WRMDs. [5, 6]

As any other study, our study has a few limitations. We did not address the percentage of therapists who did seek medical treatment or rest after WRMDs, as well as the percentage of therapists who did not consider any change in their job following injury. Furthermore, we did not collect any data about therapists who implemented self-diagnosis or did ask for help from colleagues rather than going to the hospital or visiting a medical doctor.
Jordanian physical therapists are at risk for WRMDs due to multifactorial causes. Self-protective and preventative techniques and utilisation of proper clinical skills and equipment should be implemented to reduce the WRMDs

CONCLUSION

Our main objective was to identify whether the wrong positions are the major cause that lead to pain for physiotherapists, and we found that the pain is caused by many factors, making it multifactorial. Some of the factors (life style, work hours, psychological side, etc.) affect their intensity of pain alongside their wrong positions. So, we must be sure to work on all those factors to prevent pain because physical therapists' health is the basis for them to continue in their profession, and it is a thing that cannot be ignored because, without a healthy body, the therapist would not have the ability to help any patient.

CONFLICT OF INTEREST

The authors state no conflict of interest.

DISCLOSURE STATEMENT

No author has any financial interest or has received any financial benefit from this research.

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POVREDE I PREKOMJERNI UMOR KOD FIZIOTERAPEUTA USLJED LOŠEG DRŽANJA TIJELA

Cilj ove studije je ispitati specifične faktore rizika, uključujući i navike držanja tijela, mišićno-koštanih poremećaja povezanih sa radom kod fizioterapeuta u Jordanu. Metoda: Ova studija je bila transverzalna, opservacijska studija. Rezultati: 14-10.3% je navelo da je manjak posvećenosti pravilnim položajima tijela usljed nedostatka znanja, dok je 89.7% smatralo da je razlog njihovo nepoznavanje pravilnih položaja. 84.6% terapeuta je navelo da obično osjećaju bol tokom terapija, dok je 15.3% navelo da se isti ne javlja. Zaključak: Otkrili smo da mnogi faktori uzrokuju bol pa je, prema tome, on multifaktorski. Neki od faktora (životni stil, radno vrijeme, psihološki aspekt, itd.) utiču na njihov intenzitet bola uz pogrešno držanje.

Ključne riječi: fizioterapeut, povreda, prekomjerni umor, loše držanje

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ACUTE RESPONSE TO RESISTANCE AND CONCURRENT TRAININGS ON POSTPRANDIAL GLYCAEMIA AND LIPAEMIA IN OVERWEIGHT POSTMENOPAUSAL WOMEN

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ABSTRACT

Background: Mortality rate in young women due to cardiovascular disease is 6 times lower, compared to young men. However, this gender-related difference decreases after menopause. To date, lipid metabolic responses during postprandial periods following combined exercise training are unclear in postmenopausal women. Objective: To examine the acute effect of resistance training (RT) and concurrent training (CT) on postprandial lipaemia and postprandial glycaemia in postmenopausal women. Methods: 27 women were randomly divided into RT, CT and control groups. Lipaemia, glycaemia, anthropometry, physical fitness, and nutrition were measured. Results: A reduction in the total, daily energy expenditure owing to different trainings (RT and CT, all $p < 0.005$) in postmenopausal women was observed. RT and CT performed 12 h before hypercaloric nutritional compound consumption can dramatically change the average postprandial lipid and glucose levels (RT and CT, all $p < 0.005$). The primary changes are associated with a decrease in total cholesterol and low-density lipoprotein levels in the RT group as well as a decrease in triglycerides level and an increase in high-density lipoprotein level in the group that underwent RT and aerobic exercise. Conclusion: Acute response to exercise training might have an influence on reducing energy expenditure and improving glycaemia and lipaemia in postmenopausal women.

Keywords: exercise, fitness, glycaemia, lipaemia, nutrition, postmenopause, trainings

INTRODUCTION

Mortality rate in young women with cardiovascular diseases (CVDs) is approximately 6 times lower than in young men with CVDs [1]. However, this gender-related difference decreases after menopause, when the incidence of CVDs, particularly atherosclerosis, dramatically increases in women [2, 3]. Mortality due to CVDs in female population represents 23% of total deaths worldwide, and CVDs in postmenopausal women are distinctly the main cause of death, since the postmenopausal status is considered as a non-modifiable risk factor for the development of chronic non-communicable diseases [4, 5].

CVDs and other chronic disorders, such as type II diabetes mellitus (DM2), have their origin in the

postprandial periods [6]. Eating food which is high in fat and simple carbohydrates concentrations increases the availability of lipid and blood glucose; the higher the quantity and length of lipid and glucose concentrations, the greater is their effect on the pathophysiological mechanisms underlying the development of disorders such as ischemic heart disease and DM2, respectively [7,8]. These phenomena, known as postprandial lipaemia (PPL) and postprandial glycaemia (PPG), are characterised by the return of lipid and glucose concentrations to normal values hours after food consumption [6]. However, for the large majority of people in developed or developing countries, intervals between meals do not exceed 4–6 h, which means that food-derived fat and carbohydrate levels are above the recommended concentrations, implying that people are in an almost permanent state of postprandial hyperlipaemia and hyperglycaemia [9, 10]. These phenomena are especially concerning in populations with relative cardiometabolic vulnerability, such as in postmenopausal women.

Hormonal deficiency in middle-aged women significantly increases the damaging and pathogenic capacity of postprandial periods as a result of the disproportionate intake of high fat and simple carbohydrates food [2, 7, 9]. This intensification in vulnerability is related to the decrease in the levels of oestrogen, a hormone that has a protective role against cardiometabolic disorders [2, 4]. The health impact of the postmenopausal status exponentially increases the risk of premature deaths in overweight women with low levels of physical activity (PA) [11]. Sedentary postmenopausal women have a higher prevalence of abdominal obesity, dyslipidaemia, and fasting hyperglycaemia [12], which are associated with increased secretion of pro-inflammatory cytokines, high-expression adhesion molecules (CAMs and VCAM-1), fibrinogen, and the activity of pro-oxidants [7].

PA is a non-pharmacological strategy for metabolic regulation [13] and is considered as the cornerstone for a healthier lifestyle. Regular PA contributes to prevention and treatment of chronic disorders [14, 15]. Aerobic exercise sessions may decrease the plasma levels of lipids, such as low-density lipoproteins (LDL) and very low-density lipoproteins (VLDL), as well as increase the activity of high-density lipoproteins (HDL), which play a key role in the systemic regulation of excess cholesterol [16]. However, only a few studies have assessed the acute or chronic effects of resistance training (RT) [17], primarily associated with muscle strength and endurance adaptations, on postprandial metabolic markers in postmenopausal women [18, 19].

To date, lipid metabolic responses during postprandial periods, following specific sessions of RT or a combination of aerobic and anaerobic exercises in the same session (known as concurrent training (CT)), are unclear in postmenopausal women. Therefore, the aim of this study is to examine the acute effect of RT and CT sessions on postprandial lipaemia and postprandial glycaemia in postmenopausal women.

METHODS

This quasi-experimental, random-sampling, exposure response study, determined acute changes in 2 experimental groups, stratified by 2 different types of physical activities, regarding specific blood biochemical markers, compared with a control group without training activity. A total of 27 postmenopausal women voluntarily took part in this study. The inclusion criteria were as follows: women with at least 1 year since last menstruation and those who had not undergone hormone replacement therapy. The exclusion criteria included women who had participated in some type of physical training programme in the last 6 months and those with medical records of metabolic, cardiac, or musculoskeletal disorders. We obtained informed consent from participants, and the study followed the ethical guidelines of the Declaration of Helsinki and was approved by the Ethics Committee on Human Research of the Universidad Metropolitana (reference number: 012-03312016).

Prior to (at least 5 days before the PA intervention starts) and right after the completion of the experimental protocol with exercises, all participating women were tested for blood analysis, anthropometry, physical fitness, and nutrition.

LIPID PROFILE AND INITIAL GLYCAEMIA

After at least 12 h of fasting, 5 ml of blood was drawn at the clinical laboratory for determining serum glycaemia and total cholesterol (TC), triglyceride (TG), HDL, LDL, and VLDL levels.

ANTHROPOMETRY

The weight and height of participants were determined using an electronic weighing scale (Balance Industrielles, Montreal, Canada) and a wall-mounted stadiometer (Perspective Enterprises, Portage, USA), respectively. Body mass index (BMI) was calculated. Abdominal circumference, between the 10th rib and the iliac crest, was measured using a Gulick tape. Body composition was determined using bioelectrical impedance (Tanita, model TBF-300WA Wrestling Body Composition Analyzer) to determine the percentage of body fat and lean body mass.

MUSCULAR STRENGTH, MAXIMUM DYNAMIC STRENGTH

Tests of one maximum repetition (1RM) were used for muscle groups that would participate in RT (i.e., quadriceps, hamstrings, biceps, and triceps), which was used for performing the resistance section of both experimental groups (RT and CT). The maximum load of each muscle was determined and comprised no more than 5 sets with 4-min intervals between sets.

CARDIORESPIRATORY FITNESS, PEAK OXYGEN UPTAKE

The Submaximal Rockport 1-mile Walk Test was used to calculate an approximation for peak oxygen uptake. It required participants to walk 1.6 km as fast as possible. Heart rate was monitored at the end of the test, and the total time needed to complete the distance was also recorded. The formula used was as follows: VO2 Peak (ml/kg−1/min−1) = 132.6 − (0.17 × body mass) − (0.39 × age) + (6.31 × sex) − (3.27 × time) − (0.156 × heart rate).

NUTRITIONAL BEHAVIOUR MONITORING

A self-record format was provided to record the feeding behaviour of participants during 2 days following the initial testing until the day of experimental protocol implementation. This was aimed at counteracting biases in lipid and glucose values derived from atypical nutritional patterns.

NUTRITIONAL TARGETING

On the day of experimental protocol implementation, food intake was controlled by standardising caloric intake prior to training at 60% of the basal metabolic rate (BMR) along with PA factor for each participant. The strategy included one breakfast (cereals and fruits), one snack (cereals), and one lunch (chicken meat, potatoes, and vegetables). All intakes were provided and controlled by a nutritionist. This procedure ensured that at the time of the training session, plasma lipids and glucose levels were influenced by similar nutritional behaviours and in specific amounts for each individual participant. The last food intake for each participant was scheduled at least 3 hours prior to the training activity, encouraging participants to stay hydrated.

EXPERIMENTAL PROTOCOL

All women (n = 27) were randomly categorised into 3 groups (Microsoft Excel software data randomisation function). Out of the 2 experimental groups, one underwent a session of RT (n = 9) and another underwent a session of CT (n = 9); the control group (CG) underwent only flexibility training (n = 9). For all experimental groups (i.e., RT and CT), a familiarisation session was implemented for learning the correct procedure of the exercises that were applied into the sessions. All the sessions were performed by sport professionals, and the intensity of the sessions for RT and CT was monitored

Training Sessions: Women from all groups were summoned at 5:00 p.m. to the gym to undergo their respective training sessions. After each training session, women were instructed to have just water without any caloric components until the next morning.

The RT group underwent a 10-min warm-up (walking and joint mobilisation), followed by a total of 8 resistance exercises in the following order: 1. leg press; 2. knee extension with machine; 3. knee flexion with machine; 4. elbow flexion with dumbbells; 5. elbow extension with dumbbells; 6. shoulder adduction with dumbbells from abduction in the supine position; 7. unilateral bent-over dumbbell row; and 8. unweighted abdominal training. A total of 3 series with 15 repetitions in each series at 75% of 1RM intensity and a 45-s rest interval between the series and exercises were performed. The approximate total duration of this training session was 40 min.

The CT group initially underwent a 10-min warm-up consisting of a walk (5 min) and general joint mobilisation (5 min) and then underwent the same training exercises as the RT group, except that each exercise comprised only one series with 15 repetitions at 65% of 1RM. Subsequently, they underwent 20 min of continuous pedalling on a cycle ergometer at an intensity of 70%–80% of the maximum heart rate. The approximate total duration of this training session was 40 min.

The CG underwent a training session with insignificant energy expenditure. The session comprised a 10-min warm-up (walking and joint mobilisation) and 20-min directed stretching sessions.

Biochemical Analysis: The day after the training session (12 h post training, in fasting conditions), women attended the clinical laboratory where blood samples were drawn for determining baseline glycaemia. Subsequently, a hypercaloric nutritional compound prepared by a nutritionist, equivalent to 50% of BMR with a PA factor of each woman, containing 50% lipids, 35% carbohydrates, and 15% proteins, was supplied. BMR for each woman was calculated using the Harris–Benedict formula {BMR = [655.0955 + (9.5634 × height) + (1.8449 × height) − (4.6756 × age)]} and was modified using the PA factor (+20%). After the consumption of nutritional

compound, glycaemia and lipid profile were determined at 1 every hour. A heparinised catheter, from which blood samples were drawn by an expert bacteriologist, was placed in all women, and the samples were centrifuged for 5 min at 4000 g and the serum stored at −20°C for the determination of biochemical parameters.

STATISTICAL ANALYSIS

Descriptive statistics was presented as a measure of means and respective standard deviations. For determining homogeneity, the Shapiro–Wilk and Levene normality tests were used. The analysis of variance (ANOVA) was used to determine the influence of covariates, such as age, sex or BMI, on the model between the groups. To examine the acute effect of the intervention in the outcomes examined, we used an ANOVA. Bonferroni test was used as a post hoc test. All the analyses were performed using the SPSS Statistics for Windows, version 24.00 (IBM Corp, Armonk, NY, USA). The level of significance was set at $p < 0.05$.

RESULTS

For the initial assessment conducted prior to the experimental protocol implementation, no significant differences were observed in the resulting anthropometric, biochemical and functional characteristics, as a p-value of 0.05 was observed within or between the groups, indicating homogeneity in the records (Table I).

The means ± standard deviations of energy needs of women are shown in (Table II). It can be observed that BMR and BMR adjusted for PA factor were homogeneous among each group. As variables associated with NC energy composition contribute to BMR, the subsequent results show no difference; however, similarities were noted in the proportions of fats, carbohydrates and proteins. The average total NC volume for each group did not show a variation of > 5 ml.

Table 1. Initial characteristics of women categorised into different groups

Variable	Experimental groups			P[3]
	RT group (n = 9)	CT group (n = 9)	CG (n = 9)	
Age (years)	55.44 ± 3.21	54.44 ± 4.80	54.22 ± 4.60	0.95
Anthropometric features				
Weight (kg)	70.17 ± 9.05	71.25 ± 11.22	72.23 ± 9.28	0.91
BMI (kg / m^2)	27.31 ± 2.57	28.67 ± 4.03	28.80 ± 3.35	0.64
Body fat (%)	36.90 ± 4.06	36.08 ± 4.20	36.46 ± 6.32	0.96
Lean body mass (%)	44.43 ± 3.44	42.43 ± 9.41	45.79 ± 3.74	0.41
Abdominal perimeter (cm)	94.41 ± 7.60	97.11 ± 9.60	97.31 ± 7.51	0.77
Strength and aerobic capacity				
1RM knee extension (kg)	22.56 ± 4.77	24.44 ± 3.97	23.00 ± 5.41	0.84
1RM elbow flexion (kg)	11.56 ± 4.33	10.22 ± 2.73	11.00 ± 4.12	0.53
30'' sit-to-stand test (reps)	10.11 ± 3.10	10.44 ± 2.60	11.67 ± 1.87	0.73
VO_2 Peak (ml • kg^{-1} min^{-1})	22.23 ± 4.10	21.88 ± 4.14	20.82 ± 3.70	0.52
Lipid profile and glycaemia (mg/dl)				
Total cholesterol	207.67 ± 17.10	217.30 ± 32.93	217.33 ± 40.40	0.47
Triglycerides	152.89 ± 55.21	167.44 ± 48.83	173.78 ± 54.58	0.21
LDL	132.58 ± 15.27	138.69 ± 18.86	136.63 ± 34.37	0.84
VLDL	29.73 ± 15.11	30.87 ± 10.25	34.33 ± 12.98	0.27
HDL	42.56 ± 7.87	47.22 ± 4.57	44.59 ± 7.05	0.79
Glucose	92.11 ± 10.36	93.33 ± 7.97	94.14 ± 11.24	0.82

Mean ± standard deviation of the variables analysed in each group. Repetitions (reps); millilitre per kilogram per minute (ml • kg−1 min−1).

Table 2. Energy needs and composition of the NCs among different groups

Variable	RT group (n = 9)	CT group (n = 9)	Control (n = 9)	P[3]
Energy needs (kcal)				
BMR	1354.26 ± 97.25	1338.84 ± 116.11	1364.91 ± 110.61	0.84
BMRAF	1625.12 ± 116.70	1606.60 ± 139.33	1637.89 ± 132.73	0.84
CNH total energy	812.56 ± 58.35	803.30 ± 69.66	818.95 ± 66.37	0.84
Fat	406.28 ± 29.17	401.65 ± 34.83	409.47 ± 33.18	0.84
Carbohydrates	284.40 ± 20.42	281.16 ± 24.38	286.63 ± 23.23	0.84
Protein	121.88 ± 8.75	120.50 ± 10.45	122.84 ± 9.95	0.84
CNH composition (g)				
Fat	45.14 ± 3.24	44.63 ± 3.12	45.50 ± 3.35	0.93
Carbohydrates	71.10 ± 5.11	70.29 ± 4.91	71.08 ± 5.98	0.83
Protein	30.47 ± 2.19	30.12 ± 2.10	30.71 ± 2.05	0.96
CNH volume (ml)	485.23 ± 34.84	479.71 ± 33.52	484.59 ± 28.38	0.95

Average composition of the hypercaloric nutritional compound. Column P3 shows the statistical values obtained when comparing the average values of variables in the three groups. BMR: basal metabolic rate; CNH: hypercaloric nutritional compound; BMRAF: basal metabolic rate with PA factor.

The results for PPL and PPG in each group can be observed (Fig. 1), which shows the average and standard deviations of serum fasting TC, TG, HDL, LDL, and blood glucose levels as well as pre- and post-consumption values (07:00 am) of CNH in the postprandial periods 1, 2, 3, 4, and 5 with a time interval of 60 min in between determinations (08:00 am, 09:00 am, 10:00 am, 11:00 am, and 12:00 pm). In TC and TG curves, significant differences were observed at moments 1A in favour of the RT group and 1B in favour of the experimental groups, respectively. Similarly, statistical differences were observed in the moment 3E in the experimental groups and the moment 4E in the CT group during the determination of postprandial glycaemia. No differences were found at any times in the postprandial concentrations of HDL and LDL.

Table III shows the average magnitudes of the postprandial lipaemic and glycaemic curves.

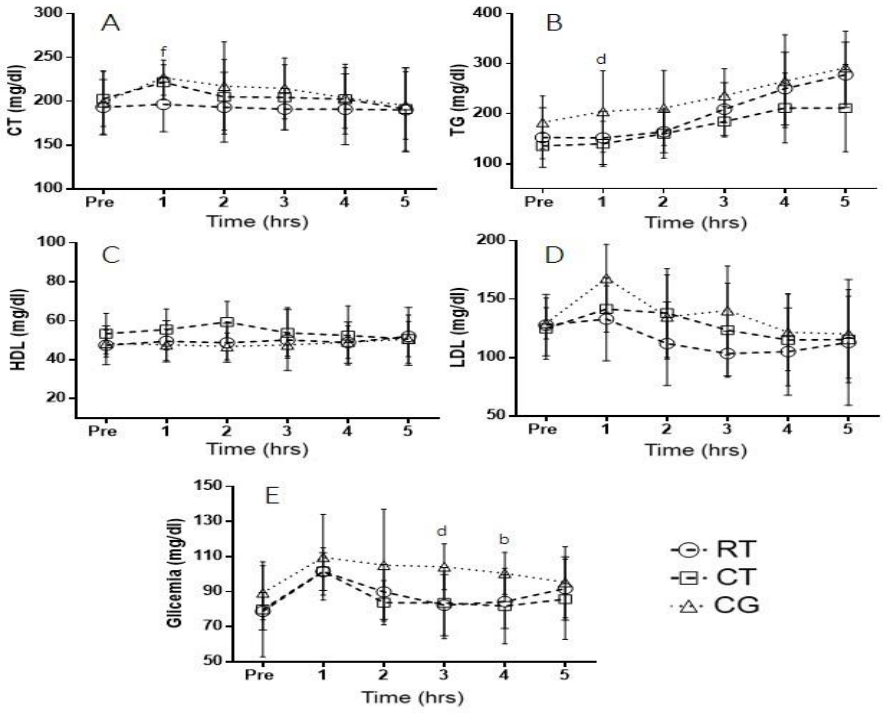

Figure 1. Postprandial lipaemia and glycaemia curves for the serum determinations of A) total cholesterol, B) triglycerides, C) HDL, D) LDL, and E) glycaemia. Statistical differences were determined by the following conventions: a) difference between the RT group and CG; b) difference between the CT group and CG; c) difference between the RT group and CT; d) difference between the RT group and the CT group with CG; e) difference between the RT group and CG with the CT group; f) difference between the CT group and the CG group with RT; g) difference among all study groups. CG: control group, CT: concurrent training, RT: resistance training.

Table 3. Comparison of the average and standard deviation values of biochemical variables in the postprandial **period among the experimental groups and the CG**

PP marker levels (mg/dl)	RT group (n = 9)	CT group (n = 9)	Control (n = 9)	P[3]
Total cholesterol	192.42 ± 35.82[a]	204.98 ± 38.06[ab]	211.64 ± 37.02[b]	0.0468
Triglycerides	210.62 ± 74.05[ab]	181.42 ± 63.68[a]	241.86 ± 100.36[b]	0.0025
HDL	49.77 ± 12.06[a]	54.15 ± 12.25[b]	48.29 ± 11.59[a]	0.0095
LDL	113.24 ± 37.78[a]	126.70 ± 45.13[ab]	136.97 ± 49.49[b]	0.0426
Glycaemia	89.94 ± 16.42[a]	87.24 ± 19.26[a]	102.95 ± 21.19[b]	0.0003

Average values of postprandial determinations of the variables studied. P3 < 0.05 indicates statistical significance. Values that do not share the same superscript letter are statistically different. RT: resistance training; CT: concurrent training; PP: postprandial period.

Statistically significant differences were observed in all biochemical variables studied. The average TC and LDL concentrations were significantly lower in the RT group than those in the CG ($P^3 < 0.05$). Conversely, the average concentrations of TG were significantly lower in the CT group than in the CG ($P^3 < 0.05$). Moreover, HDL levels were higher in the CT group than in the RT and CG groups ($P^3 < 0.05$). Finally, the average value of postprandial glycaemia was significantly lower in the experimental groups (RT and CT) than in the CG ($P^3 < 0.05$).

DISCUSSION

The main results of the study were: 1) significant reduction in the total daily energy expenditure due to different trainings, RT and CT, in postmenopausal women, evidencing that the decrease in PA prolongs and aggravates the postprandial management of energy substrates, which increases the cardiometabolic risk; and 2) RT and CT, performed approximately 12 h before hypercaloric nutritional compound consumption can dramatically change the average postprandial lipid and glucose levels in postmenopausal women. The primary changes are associated with a decrease in total cholesterol and low-density lipoprotein levels in the RT group as well as a decrease in triglycerides level and an increase in high-density lipoprotein level in the group that underwent RT and aerobic exercise.

Previous scientific literature has adequately described that the postmenopausal physiological aggravating factors, which are associated with sedentary lifestyles, reduce life expectancy and the quality of life in women [1]. Wooten, et al. [4] and Zotou, et al. [18] demonstrated that regular physical exercise is a determining factor in lipoprotein metabolism. Moreover, Moreau, et al. [10] proved an association of regular PA with the reduction of systemic inflammation and oxidative stress. Azarbal, et al. [20] have reported that PA has a protective role in the cardiac function in postmenopausal women.

The experimental design of this study was based on the theoretical premise that relates PA with a significant increase in total energy expenditure, subsequently causing a general energy deficit that can be compensated with a greater use of energy substrates in the nearest postprandial period [18]. These phenomena described by Pinto, et al. [21] indicated that in PA sessions with resistance exercises, the volume of the session is the main factor determining subsequent metabolic stress, thus increasing energy expenditure for >18 h, which directly influences lipid mobilisation and the activation of energy replacement metabolic pathways in the postprandial period [21].

Systemic lipid metabolism for each person is dependent on many factors, including diet, physical health and daily energy expenditure. The present study attempted to assess the influence of RT and a combination of RT with aerobic exercise as determining factors in postprandial metabolism. The design of the training sessions was based on those reported in the studies involving populations with similar characteristics (weight, BMI, and BMR) [17, 22]. In some specific moments of the lipaemic and glycaemic curves, statistical differences were higher in favour of the experimental groups, compared with

the CG. Nevertheless, as the primary finding of this study, RT and its combination with aerobic exercises significantly decreased the average values of the postprandial systemic concentrations of TC, TG, LDL, or glucose in overweight postmenopausal women. Nonetheless, the RT group showed a reduction in TC and LDL levels, which were only found in this group, suggesting the influence of high muscle recruitment while performing strenuous resistance exercises.

Still, we have observed that a single training session can induce the mechanisms underlying muscle energy use. Currently, to the best of our knowledge, there is only 1 study that has demonstrated the acute effects of a PA session on postprandial lipid and glucose managements [22]. Differences between studies could be due to the different experimental approaches, characteristics of the population and the experimental training programme.

One high-intensity RT session (10 exercises, 3 series at 70% of a maximum repetition) has been found to significantly reduce the disposition of postprandial TGs [23]. Unlike other studies that examined the influence of 3 different volumes of RT (1, 3, and 5 sets of 10 repetitions) on postprandial lipaemia, no significant differences were noted in relation to postprandial lipid markers in any group after the session, but in this study, the experimental group consumed more energy and fat-containing foods, compared with the CG the night before the fat tolerance test; thus, the change in the diet may have increased the possibility of masking the real effect of RT on the lipaemic response [24]. Zafeiridis, et al. [25] studied the effect of an RT session on TG levels in the postprandial period; these levels reduced over a period of 6 h after the RT session. They have also examined the effect of an aerobic exercise protocol and RT protocol with an average, total energy expenditure of 5.1 MJ and observed a decrease of 12% and 18% in postprandial lipaemia, respectively, obtaining a greater attenuation of lipid concentrations in the RT group than in the aerobic exercise group [26].
This study presents several limitations: 1) the low sample size does not allow us to generalise the findings, and 2) the lack of examination for the chronic effects of a physical activity intervention. The strengths of this study were: 1) the novelty of the study examining the acute effect of different exercise trainings in postmenopausal women, and 2) the use of variety measurements for controlling blood analysis, body composition, physical fitness, and nutrition.

CONCLUSION

The results of this study show that RT and CT performed approximately 12 h before hypercaloric nutritional compound consumption can significantly reduce energy expenditure and change the average postprandial lipid and glucose levels in postmenopausal women. The primary changes are associated with a decrease in TC and LDL levels in the RT group as well as a decrease in TG level and an increase in HDL level in the group that underwent RT and aerobic exercise. Postprandial glycaemia was significantly reduced in the PA groups, compared with the CG. Future studies with a larger sample size should be conducted to contrast or corroborate our results.

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AKUTNI ODGOVOR NA TRENING SNAGE I UPOREDNI TRENING PO PITANJU POSTPRANDIJALNE GLIKEMIJE I LIPEMIJE KOD PRETILIH ŽENA U POSTMENOPAUZI

Kontekst: Stopa smrtnosti djevojaka usljed kardiovaskularnih bolesti je 6 puta niža u odnosu na mladiće. Međutim, ova razlika u odnosu na spol se smanjuje nakon menopauze. Metabolički odgovori lipida tokom postprandijalnih perioda nakon kombinovanog vježbanja još uvijek nisu jasni kod žena u postmenopauzi. Cilj: Ispitati akutni efekat treninga snage (RT) i uporednog treninga (CT) na postprandijalnu lipemiju i postprandijalnu glikemiju kod žena u postmenopauzi. Metode: 27 žena je nasumično podijeljeno u RT, CT i kontrolnu grupu. Mjerene su lipemija, glikemija, antropometrija, fizička spremnost i ishrana. Rezultati: Uočeno je smanjenje ukupne dnevne potrošnje energije zbog različitih treninga (RT i CT, svi $p < 0,005$) kod žena u postmenopauzi. RT i CT obavljeni 12 sati prije konzumiranja hiperkaloričnih nutritivnih jedinjenja mogu dramatično promijeniti prosječne postprandijalne nivoe lipida i glukoze (RT i CT, svi $p < 0,005$). Primarne promjene su povezane sa smanjenjem ukupnog holesterola i nivoa lipoproteina niske gustine u RT grupi, kao i smanjenjem nivoa triglicerida i povećanjem nivoa lipoproteina visoke gustine u grupi koja je bila podvrgnuta RT i aerobnim vježbama. Zaključak: Akutni odgovor na vježbanje može uticati na smanjenje potrošnje energije i poboljšanje glikemije i lipemije kod žena u postmenopauzi.

Ključne riječi: vježbanje, kondicija, glikemija, lipemija, ishrana, postmenopauza, trening

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THE ROLE OF THE FACULTY OF PHYSICAL EDUCATION IN DEVELOPING CITIZENSHIP VALUES FROM THE PERSPECTIVE OF POSTGRADUATE STUDENTS AT YARMOUK UNIVERSITY

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ABSTRACT

This study aimed at identifying the role of the Faculty of Physical Education in developing citizenship values from the perspectives of postgraduate students at Yarmouk University, as well as identifying the differences in the responses of students according to the variables (gender and school year level). The researchers used a descriptive approach, and the study sample consisted of (115) students: (77) males and (38) females who were selected randomly. In order to collect the study data, a questionnaire was composed consisting of (42) paragraphs distributed into four fields (university environment, university professor, courses, and university activities). The results showed that the role of the Faculty of Physical Education at Yarmouk University in the development of citizenship values came at a high level, where the role of courses and curricula ranked first, followed by the role of the university environment in the second place, while the role of student activities came in the last place. In light of the obtained results, the researchers recommended to focus on the subject of citizenship value and give it a great importance by different departments of other universities and the faculty members, concentrating on student activities and paying attention to instilling citizenship values in students

Keywords: values, citizenship, Faculty of Physical Education, Yarmouk University, postgraduates

INTRODUCTION

The current era is witnessing many huge and rapid changes and developments resulting from the scientific and knowledge revolution in the means of information and communication technology, the concomitant emergence of globalisation with its various manifestations, and contemporary challenges that have some negative repercussions that many societies suffer from, such as the spread of violence and extremism, breach of rights and duties, weakness of adherence to authentic national values, spread of immigrant values, and other manifestations that weakened citizenship values (Alshara, 2020). To face these global changes that created a social reality with its new standards and values, societies came back to education, and considered it a lifeline and an essential means in preserving their national values and cultural identity. Akla (2006) emphasised that values have a fundamental role in the lives of

individuals, groups and societies to the extent that values have become an issue of education and that education in itself is a value process where values determine educational philosophies, goals, and processes, and govern educational institutions and curricula. Values are present in every stage of the educational process. Without values, education turns into chaos. Therefore, preparing a good citizen who adheres to his values and cultural identity has become the supreme goal that education in all its institutions and systems seeks to achieve. Accordingly, education has become one of the important areas in the consolidation of values, as it deals with young people in the stages of forming their personalities. Therefore, education has been of interest to everyone who seeks to inculcate or consolidate a value in society. If citizenship education takes place through the educational process with its various inputs and processes, the professor is also the one who gives effectiveness to all the elements of the educational process, especially in the field of forming and developing citizenship values among students, as a role model entrusted with performing the educational roles of teaching, directing and supervising the practice of activities and other educational activities based on the nature of the university and its teaching environment in general, and the Faculty of Physical Education in particular, as it is a scientific, educational, educational and development institution. Attention is always directed to these institutes in preparing qualified and scientific cadre, energies and human forces, as well as instilling the values and beliefs of society in the hearts of students and forming positive attitudes towards them (Mahmoud, 2012). It is determined that the faculties of physical education in universities, like other educational and scientific faculties, significantly contribute to the development of citizenship values by creating an appropriate educational environment that encourages students to acquire these values. This role is also determined by the university professor who must be a good role model for the students to play the role of a virtuous educator whose personality embodies those values, and who is closer to democracy, able to establish friendly relations between himself and the students, and allows them to freely express their opinion. Faculties of physical education contribute in providing student activities which are not limited to the teaching curricula because student activities play an important and prominent role in developing citizenship values in faculties of physical education through embodying the spirit of cooperation, volunteer work, tolerance, justice, equality, and political participation. It is also necessary to mention the role of curricula in developing citizenship values, including the knowledge content and attitudes that significantly contribute to this aspect.

STATEMENT OF PURPOSE

In view of the difficult circumstances that the Arab region is currently experiencing, as well as the economic, social and security problems that require good citizenship values among young people, and in light of the great dangers that society is exposed to as a result of internal and external influences, as well as the social changes we are going through in the region at the moment as a result of that which accompanied modern technology and the communications revolution with the penetration of social networking sites and the negative consequences that threaten the loss of the values of loyalty and citizenship among university students, the importance of the role that the faculties of physical education at Yarmouk University can play in developing citizenship values and belonging among students in the faculty emerges with the resources and capabilities available in it through the appropriate university environment, university professors, what the curricula and courses offer, and the student activities on a wide and continuous basis, as it enables the mobilisation and guidance of students towards the development of social values, especially citizenship values, including loyalty and belonging to the homeland, adherence to community standards, and a sense of moral responsibility towards the issues it faces. The researchers reviewed previous studies looking into this subject, and they noted the scarcity of studies that address the issue of the role of the faculties of physical and physical education in developing the values of good citizenship within the educational values and objectives, and limiting them to faculties of education, as well as the presence of weakness in the application of behaviours that encourage the development of good citizenship in some individuals; hence, the researchers decided to conduct such a study to determine the extent of the role of the Faculty of Physical Education at Yarmouk University in developing citizenship values through the university environment, courses and curricula in physical education, and university activities from the students' point of view.

STUDY QUESTIONS

- What is the level of the role played by the Faculty of Physical Education at Yarmouk University within the fields of university environment, university professor, curriculum and courses, and student activities in developing citizenship values from the students' point of view?
- Are there statistically significant differences at the significance level ($\chi \geq 0.05$) in the students' responses according to the variables (gender and school year level)?

CONCEPTS OF THE STUDY

- **Values**: a frame of reference that governs the behaviour of the individual when practicing his various activities and actions. Considering that they direct the behaviours and practices of individuals towards the socially desirable, values are a moral tool for achieving good citizenship for individuals within the society (Abdul-Raouf & Mohsen, 2013).

- **Citizenship**: the relationship between the individual and the state determined by the constitution and the laws emanating from it, which necessarily include equality in duties and rights among citizens. Citizens, and the second condition which is the availability of a democratic system whose main pillars are to achieve a balance between public rights and duties (Abu Al-Majd, 2010).

- **Citizenship values**: the normative frameworks or behavioural guidelines that positively affect the formation of the individual's personality, making him morally, behaviourally committed, and aware of the rights, duties and other basic components of good citizenship in order to prepare a professor who is proud of his national culture, possesses a culture of loyalty and belonging to his country. He is able to teach these national principles and concepts to his students (Al-Adly, 2008).

LITERATURE REVIEW

Citizenship in any state is affected by the level of political maturity of its citizens, the degree of their civilised advancement, and the prevailing values and beliefs in society (Ibrahim, 1994). Hence, citizenship moves from being merely a political consensus reflected in legal texts to becoming equality between citizens as a social and moral value and a behavioural practice whose performance expresses cultural maturity, civilised advancement and a real political awareness of treating all citizens equally without discrimination based on religion, race or gender (Al-Kuwari, 2001). With regard to the rights resulting from citizenship, they include civil and political rights. Civil rights are the rights that were born with the human being, such as the right to life, belief, thinking and building a family; they signify the right of every citizen to equality before the law without discrimination, and his right to obtain legal justice, recognising the freedom of the individual as long as it does not conflict with the law and with the freedom of others, such as freedom of opinion, freedom of expression, freedom of thought and belief, and private property, and it also includes the right to life and protection. They have the right to form associations and institutions, such as political parties and associations, and to be a member in them, and to try to influence political decisions. There are also social rights, which include access to the minimum level of social and economic well-being and the provision of social protection, which are represented in many rights, such as the right to education, health, work, non-discrimination against women and the rights of children and the elderly (Zahaira, 1999). As for the duties resulting from citizenship, they include paying taxes to contribute to the economy of the state to provide services to citizens, adherence to laws on the basis of equality and social justice, establishing security and order, performing the duty of military service, to contribute to the defence of the homeland, and the affiliation of soldiers is above sectarian and partisan affiliations and family (Ben Ouargla, 2012; Al-Ajarma, 2012).

Many institutions of socialisation inculcate the values of citizenship, and among these institutions are universities in their various faculties, including the Faculty of Physical Education, where the objectives and activities of physical education are among the most important programmes through which it is possible to instil normal social values, morals and good patriotism among students. Butz (2000) emphasises that strengthening the individual's social relations with others, improving the process of personal and social adjustment, providing the individual with values, trends and standards of correct sports behaviour to qualify him to be a good citizen in his community, is done through the practice of sports activities and participation in extracurricular activities and programmes that are considered one of the ways to integrate the individual with society. In this regard, Al Murad (2004) asserts that physical education programmes are one of the most important means to achieve the social development of the individual. Sports activities are rich in the abundance of social processes and interactions that would give the sports practitioner a large number of values, experiences and desirable social characteristics that develop the social aspects of his personality. It helps him in normalising, socialising and adapting to the requirements of society, its systems, and its social and moral standards. Bani Ismail (2017) considers that sports activities provide opportunities for the growth of acceptable national and social values, as the individual acquires a set of values from his interaction with the sports group, as the sports activity practiced with the group pushes him to use his individual skills and abilities so he learns cooperation and altruism through social interaction. The individual realises the importance of group cohesion, and the individual's participation in the sports group enables him to build and develop his social relationships, such as: friendship, social intimacy, national and moral values. Butz (2000) agrees with Shehata (2004) that the sports activities and programmes offered at the university would contribute to the development of good manners and treatment, refine students' behaviour, enhance their attitudes towards proper behaviour, and instil values and morals that are acceptable to the community,

such as helping others, cleanliness, acquaintance, altruism, and respect for others. It also contributes to the development of desirable trends, such as the student's pride in his religion, belief, homeland, values and morals, as well as working hard to develop them. Al-Khatib (2015) and Smith (2009) confirmed that sports activities constitute a fertile ground for building social relationships among students due to their dynamic, intellectual and emotional interaction, which contributes to satisfying students' needs, interests, desires and tendencies in achieving their personal goals and psychological and social development, in improving their performance of their jobs and social roles, in shaping their attitudes, values and principles, in controlling and modifying their behaviours, and in obtaining better opportunities for making alms.

From the above mentioned, the importance of developing moral, social and national values among members of society becomes clear, as it is a national necessity, especially among university students, and achieving this depends on their intellectual, social and cultural liberation.

METHODOLOGY

The researchers used a descriptive survey method for its relevance to the nature of the study.

STUDY POPULATION

The study population consisted of students attending the Faculty of Physical Education at Yarmouk University in the first semester of the year (2019-2020).

THE STUDY SAMPLE

The study sample consisted of (115) male and female students who were randomly selected from the study population. The following table describes the study sample members according to the variables: gender and school year level.

Table 1. The distribution of the study sample according to personal variables period among the experimental

Variable	Category	Frequency	Percentage
Gender	**Male**	77	67.0
	Female	38	33.0
	Total	**115**	**100.0**
Academic year	**First**	13	11.3
	Second	20	17.4
	Third	35	30.4
	Fourth	47	40.9
	Total	**115**	**100.0**

STUDY TOOL

The researchers used the questionnaire to suit the objectives and nature of the current study; the questionnaire was formed in its final form, comprising two parts, consisting of (42) items.

CONSTRUCTIVE HONESTY

In order to extract the validity indicators for all items of the study tool, the Pearson correlation coefficients were calculated between each item and the domain to which it belongs as well as the instrument as a whole as shown in table (2):

THE VALIDITY OF THE STUDY TOOL

Table 2. Correlation coefficients between the paragraphs of all domainsgroups and the CG

Correlation of the paragraphs pertaining to the role of student activities with the same field	Correlation of the paragraphs pertaining to the role of student activities with the same field	Correlation of the paragraphs pertaining to the role of the university professor with the scale as a whole	The relationship of the paragraphs pertaining to the role of the university professor with the same field	Correlation of the paragraphs pertaining to the role of curricula with the scale as a whole	Correlation of the paragraphs pertaining to the role of courses and curricula with the same field	Correlation of the paragraphs pertaining to the role of the university environment with the scale as a whole	Correlation of the paragraphs pertaining to the role of the university environment with the same field
Correlation coefficient between the paragraphs of the student activities role domain and the domain itself as well as the scale as a whole		**Correlation coefficient between the items of the domain of the university professor's role and the domain itself as well as the scale as a whole**		**Correlation coefficient between the paragraphs of the domain of courses and curricula, the domain itself, and the scale as a whole**		**Correlation coefficient between the items in the field of the role of the university environment and the field itself as well as the scale as a whole**	
**0.726	0.772**	**0.626	**0.494	**0.607	0.541**	0.776**	0.646**
0717**	0.601**	**0.751	**0.511	**0.701	0.690**	0.717**	0.727**
0.515**	0.810**	**0.710	**0.715	**0.672	0.688**	0.621**	0.538**
**0.831	**0.493	**0.621	**0.834	**0.247	0.452**	0.601**	0.764**
**0.701	**0.450	**0.671	**0.761	0.519**	0.511**	0.810**	0.769**
0.525**	**0.705	**0.705	**0.856	**0.682	**0.496	**0.561	**0.632
**0.775	**0.805	0.585**	0.463**	**0.450	**0.501	**0.741	**0.470
**0.711	0.463**	0.525**	0.580**	**0.775	**0.471	**0.801	**0.652
**0.671	**0.834	**0.710	0.410**	**0.711	**0.777	**0.493	**0.711
**0.751	**0.494	**0.671	0.474**	**0.801	**0.607	**0.682	**0.666
0.772**	0.688**	0.546**	0.515**	**0.805	0.621**	**0.701	**0.724
0.671		**0.674**		**0.809**		**0.887**	

* Acceptable and significant correlation coefficients at the significance level (α≤ 0.05)
** Acceptable and significant correlation coefficients at the significance level (α≤ 0.01).

From Table (2), it appears that the correlation coefficients between the paragraphs for all fields of study in the role of the Faculty of Physical Education at Yarmouk University in developing citizenship values and the field as a whole exceed (0.40), with the tool as a whole more than (0.30), all of which are statistically significant at the level of significance (a ≤ 0.05). This indicates the presence of strong correlation coefficients, which are acceptable coefficients for the purposes of applying the study.

STABILITY OF THE STUDY TOOL

In order to extract the stability of the study tool, the tool stability equation (Cronbach's alpha) was applied to all areas of the study of the role played by the Faculty of Physical Education at Yarmouk University in developing citizenship values, which is shown in table (3):

Table 3: Cronbach's alpha coefficients of the dimensions of the role played by the Faculty of Physical Education in developing citizenship values among students at Yarmouk University

No.	Domain	Number of paragraphs	Repeat stability coefficient	Alpha stability coefficient
1.	The role of the university environment	11	0.73	0.79
2.	The role of curricula	11	0.82	0.84
3.	The role of the university professor	10	0.85	0.87
4.	The role of student activities	10	0.78	0.77
	Scale as a whole	0.90		

From Table (3), it appears that Cronbach's alpha coefficients for the domains of the role of the Faculty of Physical Education in developing citizenship values among students ranged between (0.85 - 0.73). The highest was "the domain of the role of the university professor", and the lowest was "the domain of the role of the university environment", and the Cronbach's alpha coefficient of the scale was (0.90) as a whole; all coefficients of stability and repeatability are high and acceptable for the purposes of the study.

SCALE CORRECTION

The scale in its final form consisted of (42) items, where the researchers used the Likert scale for the five-year gradient in order to reveal the role of the Faculty of Physical Education in developing citizenship values among students at Yarmouk University. The scale was given as: to a very large degree (5), to a large degree (4), with a medium degree (3), with a low degree (2), with a very low degree (1). It was marked by placing a sign (√) in front of the answer that reflects the degree of their agreement, and the following classification was relied upon to judge the arithmetic averages as follows:

- Less than 2.33 - low.
- From 2.34 to 3.66 - medium.
- From 3.67 to 5.00 - high.

STUDY VARIABLES

- The independent variable: Gender: (male and female); The academic year: (first, second, third, and fourth).
- The dependent variable: Students' responses to the role of the Faculty of Physical Education at Yarmouk University in developing citizenship values.

DATA ANALYSIS

First question: What is the level of the role of the Faculty of Physical Education at Yarmouk University in developing citizenship values from the students' point of view (university environment, university professor, student activities and courses)?

To answer this question, means and standard deviations were calculated for each of the domains (university environment, university professor, student activities and courses) in developing citizenship values at Yarmouk University, and table (4) shows the results:

Table 4: means and standard deviations of university environment, university professor, student activities and courses in developing citizenship values at the Faculty of Physical Education, Yarmouk University

No.	Rank	Domain	Mean	SD	Level
1	2	**The role of curricula**	3.95	0.87	High
2	1	**The role of the university environment**	3.93	0.70	High
3	3	**The role of the university professor**	3.88	0.78	High
4	4	**The role of student activities**	3.86	0.87	High
Total	**High**			**0.70**	**3.90**

It is noted from Table (4) that the averages of the fields ranged between (3.86 - 3.95), where the field of the role of curricula ranked first with an average of (3.95) and at a high level, followed by the field of the role of the university environment in the second place with an average of (3.93) at a high level, while the field of the role of student activities ranked last with an average of (3.86) at a high level, and the overall arithmetic mean of (3.90) at a high level. The researchers also calculated means and standard deviations of the answers provided by the study sample members to the paragraphs of each field separately, and the results came as follows:

THE ROLE OF THE UNIVERSITY ENVIRONMENT

The mean of the responses of the study sample to the role of the university environment ranged between 3.62 and 4.34, where paragraph No. 1 came in the first place, which states: "allow students to socialise" with an average of (4.34) and at a high level, while paragraph No. 11 came in the last rank, which states: "promotes the principle of justice, equality and equal opportunities during the application of laws and regulations" with a mean of (3.62) and at a high level. The arithmetic mean of the answers on the role of the university environment as a whole ranked (3.93) with a high level.

THE ROLE OF CURRICULA

The mean of the responses provided by the study sample on the role of curricula ranged between (3.80 - 4.23), where paragraph No. 9 came in the first place, which states: "develops the principle of freedom of expression and the confidence of positive dialogue among the students" with a mean of (4.23) and at a high level, while paragraph No. 7 came in the last rank: "promote the values of the spirit of serious thinking are strengthened by the problems of society" with a mean of (3.80) and at a high level. The total mean of the samples' answers as a whole were (3.95) at a high level.

PROFESSOR'S ROLE

The mean of the answers of the study sample to the role of professor ranged between (3.68 - 4.18), where paragraph No.(1) came in the first place, which states: "keen to translate his positive experiences into actual practice" with an average of (4.18) at a high level, while paragraph No. (10) came in the last rank and its text is as follows: "uses evaluation methods that do not measure memorisation," with an average of (3.68) at a high level; the arithmetic mean of the answers provided by the study sample members on the role of a university professor as a whole came as (3.88) at a high level.

THE ROLE OF STUDENT ACTIVITIES

The means of the responses of the study sample to the student activities' paragraphs ranged between 3.60 and 4.05, where paragraph No. 6 came in the first place, which states: "it translates the values of citizenship (such as identity, belonging, freedom, and participation). The average reached (4.05) at a high level, while paragraph No. (4) came in the last rank and its text is as follows: "it allows the participation of parents side by side with students" with an average of (3.60) at a high level. The average of the answers on the role of student activities as a whole is (3.86) at a high level.

The second question: Are there statistically significant differences at the significance level (a ≥ 0.05) in the students' responses according to the variables (gender and school year level)?

To answer this question, means and standard deviations of students' responses were calculated according to the variables (gender and school year level) for all fields of study.

The results showed that there are no statistically significant differences at the significance level (a = 0.05) in the total score for the role played by university environment, university professor, curricula, and student's activities in developing citizenship values among students of the Faculty of Physical Education at Yarmouk University attributed to the gender and academic year variables, where the (F) values were not statistically significant.

CONCLUSION

The averages of the fields ranged between (3.86 - 3.95), where the field of the role of curricula ranked first, followed by the role of the university environment in the second place, while the role of student activities came in the last rank. The researchers attribute this to the fact that there is a curriculum for the subject of National Education at the university within the study plan, which is a mandatory requirement for university students of different specialisations. Just as the Faculty of Physical Education assumes its responsibilities in consolidating and developing citizenship values among students, future professors, through the curricula that, by means of its various themes and activities, can develop students' awareness of citizenship issues, as the curricula in Jordanian universities focus in their content on developing the principle of freedom of expression and the culture of positive dialogue among students, and is concerned with their acquisition of national identity, attachment to the homeland, a sense of belonging and concepts of equality. The results of this study agree with the results of Shamanic (2012) that revealed the role of the curricula in supporting identity and belonging among students. These results of a study contradict the study of Morsi and Abdullah (2011) as well as Raed and Muhammad (2015) which indicated that there is a weakness in the curricula's connection with the civic goals of society.

The role of the university environment came in second place, as this result is attributed to the fact that the university plays an active role in educating students about the principles of citizenship in light of the effects of contemporary global challenges, and actively contributes to educating students about the principles of citizenship as it is concerned with the educational process in the university environment in all its aspects and allows social communication, which generates feelings of confidence and pride in the faculty. It also develops a spirit of cooperation between students themselves and between students and professors, and allows students to express their opinion completely freely and encourages them to use rational solutions and renounce violence. It also provides an opportunity for students to satisfy their cognitive, skill, emotional and behavioural needs, and dialogue prevails over the method of interaction between students, professors and workers, and the university embodies the principle of cooperative work, participation and teamwork in its management in planning, implementation and evaluation.

The university provides the opportunity for students to participate in the decision-making process. It supports the confidence of citizenship without intellectual and cognitive closure. It promotes the principle of justice, equality and equal opportunities during the application of regulations and laws. All this leads to a conscious university leadership capable of enriching the university environment with the principles and citizenship values. This result is consistent with the results of Al-Thubaity et al. (2016) and Al-Qahtani et al. (2010), where the results showed that the university contributes to the level of students' awareness of the principles of citizenship in light of the effects of contemporary global challenges. Loyalty to the homeland represents the highest values of citizenship, followed by commitment to the standards of society, and then a sense of moral responsibility towards society.

With regard to the role of the university professor, it came in third place, and it must be noted that the professor is the one who gives effectiveness to all elements of the educational process, especially in the field of forming and developing citizenship values among students as a role model who is entrusted with performing educational roles, such as teaching and directing as well as supervising the practice of activities and other educational activities. It is determined that the faculties of physical education in universities, like other educational and scientific faculties, significantly contribute to the development of citizenship values by creating an appropriate educational climate and environment that encourages students to acquire these values. This role is determined by the university professor who must be a good role model for the students to play the role of a virtuous educator whose personality embodies those values, and who is closer to democracy and forms friendly relations between himself and the students, and allows them express their opinion. This result is attributed to the fact that the performance of the university professor as a role model is the main tool influencing the formulation of students' attitudes towards sound citizenship. The university professor is keen to translate his positive experiences into actual practice, he uses modern teaching methods (such as brainstorming, discussion, and problem solving) that contribute to the development of citizenship values, promotes the values of tolerance among students, deals with a degree of flexibility and tolerance and deals rationally with students as well as urges students to use the values of cooperation among them. His behaviour matches his ideas in his educational situations, respects students' independence and thinking and moves away from traditional methods of teaching. This result is in agreement with the study conducted by Al-Azmi et al. (2011) which indicated the role of professors in developing national values and that it came to a large extent in all fields, and the study conducted by Son (2010) revealed the extent to which the university professor played his role in developing citizenship values, especially the values of belonging, loyalty, tolerance, respect for the other, the values of political awareness, and the values of voluntary teamwork.

The role of student activities at the university in developing citizenship values was also at a high degree. The researchers attributed this to the fact that the Faculty of Physical Education provides student activities and is not limited to teaching curricula only since student activities play an important and prominent role in developing citizenship values by embodying the spirit of cooperation between students, volunteer work, tolerance, justice, equality, and political participation in the university.

The activation of academic and non-academic activities in the Faculty of Physical Education in order to enhance and preserve the principles of citizenship, and the student activities offered by the university are based on holding cultural seminars where officials are invited to discuss various issues, in addition to voluntary activities such as camps and participation in tournaments, as these student activities enhance the concepts of citizenship such as identity, belonging and political participation because many of these activities are related to the issues and concerns of society and provide opportunities for community institutions to participate in them, in addition to parents' participating side by side with students.

RECOMMENDATIONS

In light of the obtained results, the researchers recommend the following:

1. The importance of preparing students in the field of citizenship education so that they can achieve the national aspirations of social harmony, unity and nation-building.
2. Focusing on citizenship values in preparing physical and sports education curricula in the faculties of physical education in universities and other educational institutions.

3. Assessing citizenship values in the curriculum of the faculties of physical education in a way that achieves harmony and integration with the maturity of the age and intellectual level of students in building curricula.

4. The necessity of preparing forums and seminars for students and making them aware of values and their benefits and studying them by organising sports courses and activities with a focus on values and national belonging.

5. Knowing the educational impact of the university professor's role in the faculties of physical education in universities during teaching in instilling citizenship values among students.

6. Raising awareness among students about the importance of citizenship values during lectures and university sports as well as national activities.

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ULOGA FAKULTETA ZA FIZIČKO OBRAZOVANJE U RAZVIJANJU GRAĐANSKIH VRIJEDNOSTI IZ PERSPEKTIVE STUDENATA POSTDIPLOMSKIH STUDIJA NA YARMOUK UNIVERZITETU

Ovo istraživanje je imalo za cilj identifikovati ulogu Fakulteta za fizičko obrazovanje u razvijanju građanskih vrijednosti iz perspektive studenata postdiplomskih studija na Yarmouk univerzitetu, kao i utvrditi razlike u odgovorima studenata prema varijablama (spol i akademska godina) Istraživači su koristili deskriptivni pristup, a uzorak istraživanja se sastojao iz (115) studenata: (77) muškog i (38) ženskog spola, a koji su nasumično odabrani. Upitnik koji sadrži (42) čestice podijeljene na četiri polja (univerzitetsko okruženje, univerzitetski profesor, nastavni predmeti i univerzitetske aktivnosti) je izrađen kako bi se prikupili podaci u istraživanju. Rezultati su pokazali da je uloga Fakulteta za fizičko obrazovanje Yarmouk univerziteta u razvijanju građanskih vrijednosti na visokom nivou, a uloga nastavnih predmeta i planova i programa je zauzela prvo mjesto, dok je uloga univerzitetskog okruženja koja slijedi zauzela drugo mjesto sa ulogom studentskih aktivnosti na posljednjem mjestu. Uzimajući u obzir dobivene rezultate istraživači su predložili da se fokusira na temu građanskih vrijednosti te da im različiti odsjeci drugih univerziteta i akademsko osoblje pridaju veći značaj koncentrišući se na studentske aktivnosti i obraćajući pažnju na usađivanje vrijednosti kod studenata.

Ključne riječi: vrijednosti, građanstvo, Fakultet za fizičko obrazovanje, Yarmouk univerzitet, studenti postdiplomskih studija

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THE EFFECT OF CORE MUSCLE STRENGTHENING WORKOUTS IN IMPROVING THE STATIC BALANCE OF JUDO PLAYERS

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ABSTRACT

Core muscles have multiple benefits for athletes and non-athletes, such as their importance in improving motor performance and preventing injuries. Judo players perform various movements during training or matches, such as bending, rotation and flexion, which depend heavily on the muscles around the torso as well as the balance requirements during throwing to reach the optimal position of the throw. This study aimed to verify the effectiveness of intense training during the preparation period to strengthen the core muscles on the static balance of judo players. In total, 24 judo players participated in the study to form two groups: an experimental group (12 players), who were trained via intense core muscle workouts (8 exercises) according to specific instructions (three times per week/6 weeks), and a control group (12 players), who were trained on various muscle groups (three times per week/6 weeks). The flamingo test (European Fitness Test – Eurofit) was applied to measure the static balance of the players (pre-test – post-test). The results showed an improvement in the static balance for both groups, and the comparison between the two groups showed a significant superiority for the experimental group in terms of balance due to the effect of core muscle strengthening workouts. The results obtained confirm the effectiveness of core muscle strengthening workouts in improving the static balance of judo players. Therefore, coaches can use these workouts during the preparation period and can manage training loads according to the characteristics of the players by regularly measuring the static balance through field or laboratory tests, and the results of these tests can help in planning training programmes.

Keywords: core muscles, static balance, judo

INTRODUCTION

Throwing skills in judo include a skill that requires balance and stability during the throwing phase to specifically achieve effectiveness in performing a throw, especially those performed from standing on one leg, such as Uchi Mata, Hari Joshi and Osoto Gary. This requires improvement of balance for players in training, which can be achieved by training the core muscles that have a major role in the player's balance and stability.

By observing unsuccessful throwing in junior competitions, it has been shown that many players lose balance during the throwing phase or do not use the correct throwing position.

In judo, balance is of utmost importance, as the athletes need to maintain posture control and good balance to avoid losing points and ultimately the match (Alonso et al., 2009; Aboelwafa, 2021).

A number of scientific studies that have studied the reasons for failing throwing attempts in judo have described the many reasons that lead to this, including the player taking a correct position that enables him to balance to achieve the throw effectively (Kajmovic & Huremovic, 2017; Gutiérrez-Santiago et al., 2013; Gutiérrez, Prieto, & Cancela, 2009; Prieto et al., 2016; Prieto Lage et al., 2014).

The muscles around the pelvis, lower back and hip regions constitute what is referred to as the "core", and they play a principal role in the transfer of

forces between the trunk and extremities (Kellis et al., 2020). Core muscles are responsible for all the major movements of the body. These muscles give strength and stability to the movements, such as bending, twisting, crouching, etc. (Chakravarthy & Vivekanandhan, 2020).

Core strengthening is a very important part of physical preparation. It is not only for athletes but also for regular people. These muscles play a vital role in bending, twisting, sitting or standing for time periods during daily activity (Chakravarthy & Vivekanandhan, (2020). The training of core muscles is key in sports training to improve performance and reduce the risk of injuries (Nuhmani, 2021; Huxel Bliven & Anderson, 2013).

Therefore, it is important to include core muscle strengthening workouts in training programmes in judo to improve performance as well as to prevent injuries, which can be dangerous. This study examined the effect and effectiveness of core muscle workouts in improving the static balance of judo players, and the results found can be suggested to coaches.

MATERIALS AND METHODS

The subjects included 24 male judo players from local clubs in Egypt who participated in the study. They have at least five years of training experience, and they participated in multiple local championships; the players' data are shown in Table No. (1).

All participating players were at the beginning of the preparation period and did not suffer from any injuries. We obtained consent from all the players to participate in the study, and they pledged to perform the exercises according to the instructions of the researcher and assistant coaches.

The players were randomly assigned to experimental and control groups. The first group (the experimental group) included 12 players who were trained for a period of 6 weeks with core muscle strengthening workouts according to the performance instructions shown in Figure No. (1).

The second group (the control group) was not trained in the same workouts assigned to the first group, except for the judo skills exercises that they participated in.

The training instructions were explained to the players by the researcher and the assistant coaches, and their questions about the study were answered and motivated them to attend and participate effectively to obtain accurate results.

The balance test (flamingo) from the European test battery was used to measure the static balance of the players. In this test, each player stands on one foot on a crossbar (1-inch wide, 1-inch high and 20-inches long) and holds the other foot by the ankle using the hand. Each player stood for one minute, and we counted the number of attempts in which they failed, giving the player a rest for 30 seconds, and then, we repeated the test with another leg. The average was calculated for the two measures (Adam et al., 1987; Jakobsen et al., 2011; Aboelwafa et al., 2019).

The intensive training for core muscles lasted for 6 weeks and included 8 workouts aimed at strengthening the core muscles (rectus abdominis, external and internal obliques, transverse abdominis, multifidus, quadratus lumborum, and lumbar erector spinae).

The experimental group underwent intensive training with core muscle strengthening workouts for a period of 6 weeks (three times per week) within the training unit during the preparation period, and the physical training is shown in Figure No. (1). However, the control group did not undergo the same intensive training for core muscles, but they trained as usual, which included a variety of muscle groups.

Figure 1. Core Muscle Strengthening Workouts

Protocol
The pre-test for static balance was measured using the flamingo test for both groups one day before the start of training, and the post-test for static balance was measured one day after the end of the specified training period (6 weeks).

Statistical analysis was performed using IBM SPSS (Version 21.0). The Shapiro–Wilk test ($p < 0.05$) was applied, and the pre-test and post-test data from each group were compared via the paired sample t-test. Data are presented as the mean and standard deviation of the mean.

RESULTS:

All participants in the study, whose characteristics are shown in Table No. (1), were regularly participating in the exercises, and took part in the performance according to the training programme for each group.

Table 1. The players' data

Group	No.	Age (years)	Body mass (kg)	Body height (cm)	BMI (kg/m²)	Training experience (years)
Experimental	10	17.08	70.38	1.78	22.35	6.1
Control	10	17.62	71.35	1.79	22.40	6.6

Figure No. (2) shows the differences between the two groups in the pre- and post-measurements of the balance test (flamingo) after 6 weeks of applying the programme. The decreasing numbers in the figure indicate the balance level progress in the flamingo test. Both groups achieved an increase in their balance level with a different value for each group. Comparing the results of the two groups, the experimental group was significantly superior.

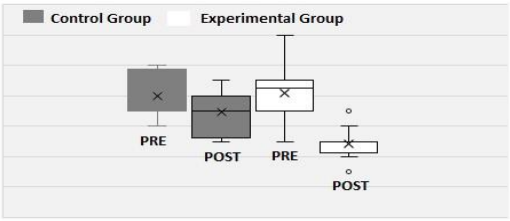

Figure 2. Pre-Test and Post-Test Measurement of the Flamingo Test

DISCUSSION AND IMPLICATIONS:

According to the player data and the physical training programme during the preparation period, which aimed to strengthen the core muscles to improve the static balance, and the statistical analysis, the results of our study showed that there was progress for both groups (experimental and control) in the flamingo test, but the progress in the experimental group was very high, compared to the post-measurements of the control group. This difference can be explained by the effect of core muscle strengthening workouts during the preparation period for the experimental group to improve static balance.

The progress of the control group was limited, compared to the experimental group, as the physical exercises for this group included the muscle groups in all parts of the body, and the intensity of the exercises differed from the exercises for the experimental group.

Improving the level of balance is closely associated to these results due to the role of core muscles in balance and stability during motor performance.

When performing throwing skills in judo, the player makes rotation and flexion movements around the main axis to reach the most appropriate position for throwing. This requires strong core muscles that enable the player to maintain balance and stability during performance, especially in the throwing phase, as most of the skills during the throwing phase require flexion movement in the forward and down direction to throw the defender. This requires a large contraction force of the rectus abdominis muscles, which is one of the important core muscles, in addition to the contribution of other core muscles to support performance and maintain balance and stability of the body.

There are throwing skills in judo that are performed from one foot. This means that the player needs balance and stability during the throwing phase for success of the throwing phase, and the skills of the player must be supported by physical abilities to achieve a successful throwing phase. Strengthening the core muscles can achieve this according to the results of the current study with the appropriate intensity during the training period.

Strengthening the core muscles has another benefit besides supporting and improving motor performance, including the prevention of injuries, which can stop the player from continuing training and competitions.

CONCLUSION

The effect of intense workouts to strengthen the core muscles and their role in improving the static balance of judo players has been verified, which benefits skill performance, and this improvement can be observed during training and competitions.

The researcher suggests using the training programme used in this study to strengthen the core muscles during the preparation period with a controlled training load according to the characteristics and type of players. The preparation period is the most suitable for improving balance, for strengthening the core muscles with varying intensity during training periods (preparation, competitions) and for gradation in the load intensity during the training progress.

Coaches can use core muscle strengthening workouts with high-level players by adding weights to some of the workouts to achieve high load levels.

The importance of measuring the balance of judo players periodically before and during the training

season via simple physical measurements, such as the flamingo test (the European fitness test), or via laboratory tests to verify the players' balance levels to provide accurate data of the players will enable improved training process planning.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the author.

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UTICAJ VJEŽBI ZA JAČANJE MIŠIĆA TRUPA NA POBOLJŠANJE STATIČKE RAVNOTEŽE DŽUDISTA

Mišići trupa imaju višestruke koristi za sportiste i one koji to nisu, poput njihovog značaja u poboljšanju motoričke izvedbe i sprječavanju povreda. Džudisti izvode različite pokrete tokom treninga ili takmičenja, poput savijanja, rotacije i pregibanja, a što u velikoj mjeri zavisi od mišića koji se nalaze oko trupa, kao i od potrebe za održavanjem ravnoteže tokom bacanja kako bi postigli optimalni položaj bacanja. Ova studija je nastojala provjeriti uticaj intenzivnog treninga za jačanje mišića trupa tokom perioda priprema na statičku ravnotežu džudista. U studiji je učestvovalo ukupno 24 džudista koji su sačinjavali dvije grupe: eksperimentalnu grupu (12 sportista) koji su podvrgnuti intenzivnom treningu mišića trupa (8 vježbi) prema posebnim uputama (tri puta sedmično/6 sedmica) i kontrolnu grupu (12 sportista) koji su podvrgnuti treningu različitih mišićnih grupa (tri puta sedmično/6 sedmica). Flamingo test (Eurofit baterija testova) je primijenjen za mjerenje statičke ravnoteže sportista (predtestiranje i posttestiranje). Rezultati su pokazali poboljšanje statičke ravnoteže kod obje grupe, a poređenje između ove dvije grupe je ukazalo na značajnu nadmoć eksperimentalne grupe u smislu ravnoteže zbog uticaja vježbi jačanja mišića trupa. Dobiveni rezultati potvrđuju efikasnost vježbi jačanja mišića trupa u poboljšanju statičke ravnoteže džudista. Prema tome, treneri mogu koristiti ove vježbe tokom perioda priprema te mogu prilagoditi opterećenje tokom treninga prema karakteristikama sportista redovno mjereći statičku ravnotežu putem laboratorijskih i terenskih testova, a rezultati ovih testova mogu pomoći u planiranju programa treninga.

Ključne riječi: mišići trupa, statička ravnoteža, džudo

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CORRELATION BETWEEN BICYCLE GEOMETRY AND THE LYSHOLM SCORE (KNEE) IN YOUNG HEALTHY ADULT MALE CYCLISTS

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ABSTRACT

Objective: To establish a correlation between bicycle geometry and the Lysholm score (knee) in young healthy adult male cyclists. Design: A correlational study. Setting: Delhi/NCR region. Participants: One hundred male cyclists were included in the study based on inclusion and exclusion criteria. Details of the protocol, including benefits, objectives and purpose of the study, were described to them, and then, if they met the requirements for participation, they were requested to complete a consent form for participation in the study. Main Outcome Measures: Demographic details of the subjects were taken, i.e., name, age, height, and weight. Then, the saddle to pedal distance and the handlebar to saddle distance were measured and noted using a measuring tape. Further assessment forms were filled in. Results: There was no statistically significant correlation between the saddle to pedal distance and the Lysholm score. Similarly, there was no association between the handlebar to saddle distance and the Lysholm score that was statistically significant. Conclusion: Though the present set of data produces a slight positive relationship between the saddle to pedal distance and the handlebar to saddle distance with the Lysholm score, it provides a basis to support the alternate hypothesis, i.e., "there is a significant correlation between the Lysholm score (knee) and bicycle geometry in young healthy adult male cyclists" as well as highlights the need for a comprehensive study on this.

Keywords: bicycle geometry, Lysholm score, saddle to pedal distance, handlebar to saddle distance, cyclist

INTRODUCTION

Cycling is the utmost enjoyable aerobic exercise encouraged for the advancement of an individual's health that additionally makes it one of the foremost fascinating modes of locomotion. With the increase in pedalling time, injuries encountered during cycling have become very common. Most of them account for overuse injuries involving more of the lower body joints, notably the knee joint. While cyclists suffer a high rate of severe injuries on a statistical basis, overuse injuries are much harder to predict due to their complexity.

Numerous studies have been undertaken to determine the various causes of cycling-related discomfort and injury. For example, in combination with various sporting activities, bicycle misalignment, inexperience or a lack of pre-ride training, and long-distance riding have all been suggested as potential triggers for knee pain (non-traumatic). Numerous studies indicate that improper bicycle fit and alignment/geometry, insufficient training, and insufficient equipment are significant contributory variables, and that measures should be taken to

control these issues in order to limit the occurrence of overuse injuries and time off training. Clinicians should have a working knowledge of bicycle fitting and the role of anatomical variables and training faults in repetitive stress injuries. Regardless of the riding surface, the bicycle can either assist the rider's comfort or compel him into an undesirable riding position. Certain adjustments are necessary to maintain the rider's balance and comfort, and hence an energy-saving configuration will be discussed later.

Bicycle geometry is the assembly of key measurements (lengths and angles) that define a particular bicycle's configuration. Knowing a bicycle's geometry, mainly the saddle to pedal distance and the saddle to handlebar distance, can help us understand how a bicycle will handle, feel, and what comfort it can offer to the rider (Figure 1). If one gets the right size and right kind of bicycle, chances are that its geometry is going to serve him/her better. Incorrect bicycle geometry can increase the cyclists' risk of injury and decrease their dynamic performance.

Figure 1. Measurement of saddle-pedal and saddle-handlebar distance

The next step is to adjust the distance between the handlebar and the saddle (saddle-handlebar-distance). With handlebars raised significantly above the saddle, the rider experiences less flexion in the low back and less stress on the upper extremity, resulting in a more favourable position. Appropriate saddle height is critical because saddle heights that are too low or too high have an effect on the knee angle and, consequently, on the mechanical work and pedalling efficiency. A saddle height that is placed incorrectly may result in knee damage and lower back pain. The appropriate method to select optimal saddle height is still unknown. A properly adjusted seat height helps avoid injury and increases rider economy and power by optimising the knee angle, which allows the cyclist to stay seated as long as possible. As a result, his buttocks bear the majority of his weight. Additionally, when contrasted to a low saddle position, the activation of appropriate muscles for pedalling is optimal, which reduces femoropatellar pressure in the virtually extended knee.

Reduced saddle height has been associated with higher compressive stress at the patellofemoral joint and the development of overuse knee discomfort in the laboratory. When the saddle is set too high, the higher ankle joint must be hyper-flexed, exhausting the flexor group of muscles. Additionally, the pressure placed mostly on the buttocks raises the loads in this region of the body. After adjusting the saddle to the proper position, the saddle's angulation must be adjusted. Most bicycles feature a horizontally fixed saddle, which aids in evenly distributing the stress across the buttocks. A somewhat anteriorly tilted saddle distributes stresses more evenly across the sciatic bone and relieves pressure on the pubic area. When the incline is too high, the rider begins to slide downward and must reposition himself using his knees and arms. On the one hand, this posture consumes energy; on the other hand, it forces the lower back into an abnormally upright position, impairing its capacity to absorb shocks. In comparison, a posteriorly raised saddle position places an excessive amount of pressure on the pubic area. This is inconvenient for females and males alike, as it forces the rider into such an uncomfortable pedalling position.

Lysholm score has the individual components that correlate with many cycling-specific injuries such as pain during flexion-extension activities, knee instability, swelling, clicking/popping sounds, etc. Initially developed for physician administration, the Lysholm score was verified in patients with ACL and meniscal injuries. Additionally, it has been validated as a self-administered instrument for assessing symptoms and performance in individuals who have sustained a myriad of knee injuries.

METHODOLOGY

Research Design
A correlational study design was adopted.

Sample Size
A total number of 100 male subjects were taken for participation in this study.

Study Centre and Location
Delhi, Gurgaon and Faridabad

Sampling Method
Convenience sampling

The above-mentioned number of subjects were screened and recruited according to the following criteria:

Inclusion Criteria:
The inclusion criteria were as follows: (i) male cyclists, (ii) age between 18-40 years, (iii) hardtail suspension bicycle, (iv) cyclists who have been cycling for ≥ 1 month, (v) frequency of cycling at least twice or three times per week

Exclusion Criteria:
The exclusion criteria were as follows: (i) female cyclists, (ii) history of recent acute injuries, (iii) history of any orthopaedic conditions, (iv) degenerative changes, (v) neurological disorders and those cyclists who were unwilling to participate in the study

Procedure
This study was conducted on 100 male cyclists between the ages of 18 and 40 years who were randomly chosen for the study from the study area. All cyclists were familiarised with the objective and the beneficial outcome of the study in detail. After being well informed of the procedure, those willing to participate were given a consent form to sign as per the guidelines of the Indian Council of Medical Research (ICMR, 2000) based on the inclusion and exclusion criteria (Figure 2).

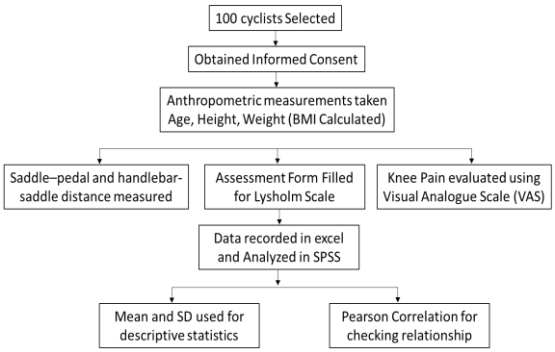

Figure 2: Study protocol

Anthropometric data, such as age, height and weight, were recorded for all the cyclists. The investigation was aimed to detect knee pain in young healthy adult male cyclists and was carried out in the Delhi/NCR area in order to get more detailed information about the influence of specific bicycle adjustments on knee pain. Knee pain was evaluated separately, making use of the Visual Analogue Scale (VAS) for pain assessment.

All the cyclist were rated for knee function using the Lysholm knee scale. This 100-point scoring system consists of eight items. Eight factors are scored to generate an overall score on a 0 to 100 point scale. The assignment is then graded as "outstanding" if it receives 95 to 100 points; "good" if it receives 84 to 94 points; "fair" if it receives 65 to 83 points; or "bad" if it receives less than 65 points. The limp, support and locking aspects are provide a combined 23 points; pain and instability are valued 25 points each; swelling and stair climbing are valued 10 points each, and squatting is given 5 points. Increased scores imply a more beneficial outcome associated with less symptoms or disability.

In addition to detecting knee pain in cyclists, we analysed the correlation between knee pain and various study parameters such as anthropometric parameters, frame size, bicycle adjustments, etc. To evaluate the bicycle adjustment, the saddle to pedal distance and the saddle to handlebar distance were noted.

STATISTICAL ANALYSIS

MS-Excel 2010 was used to enter the data, and SPSS version 23 was used to analyse it. For most of the general characteristics, descriptive statistics were used. P value less than 0.05 was taken as significant. The Pearson's correlation coefficient test was used to find the correlation between the Lysholm score and different variables.

RESULTS

Altogether, 100 subjects were included in this study. The average age of the cyclists was 26.59 ± 7.81 years. The mean weight of all the cyclists included in the study was 74.08 ± 13.50 kg, and the mean height was 172.73 ± 6.28 cm. BMI was calculated using a standard formula from weight and height with an average of 24.87 ± 4.55 kg/m^2. On examination of the bicycle, the average frame size was found to be 19.1 ± 1.57 inches, the average saddle-pedal distance was 26.0 ± 2.12 inches, and the saddle-handlebar distance was 23.03 ± 1.89 inches. Out of 100 cyclists, 38% of them reported having knee pain. The average Lysholm score of all the cyclists was found to be 94.06 (range = 64-100) which is considered as 'good' and indicates a better outcome with fewer symptoms or disability. Knee pain was evaluated using the Visual Analogue Scale (VAS), and the mean of VAS in right knee and left knee was almost the same.

Figure 3 demonstrates the distribution of the Lysholm score of all the cyclists enrolled in the present study. The Lysholm score range was between 60 and 100.

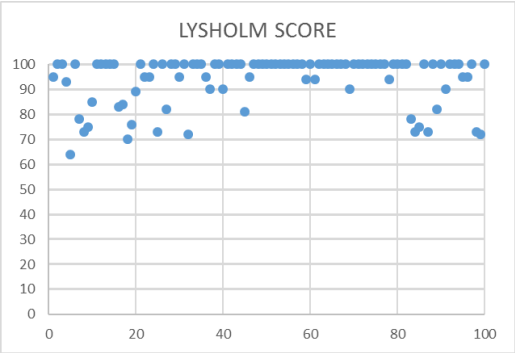

Figure 3: Distribution of the Lysholm score (n = 100) obtained from male cyclists

A weak linear association, i.e., a positive correlation was observed between the saddle to pedal distance and the Lysholm score (r = +0.091, p = 0.370), which was statistically insignificant. A weak linear association, that is, a positive correlation was observed between the handlebar to saddle distance and the Lysholm score (r = +0.148, p = 0.141), which is statistically insignificant. A weak negative association was found between the frame size and the Lysholm score (r = -0.89, p = 0.376) (Table 1).

Cluster formation was seen between the saddle-pedal distance and the Lysholm score. The saddle-pedal distance ranging between 20-30 inches has a deep cluster formation with respect to the Lysholm score ranging between 60 and 100. The cluster between the handlebar-saddle distance and the Lysholm score showed that the handlebar-saddle distance ranging between 20-25 Inches lay within the Lysholm score range of 60 to 100. Further, most frame sizes lay between 18-20 inches with respect to the Lysholm score ranging between 60 and 100 (Figure 4).

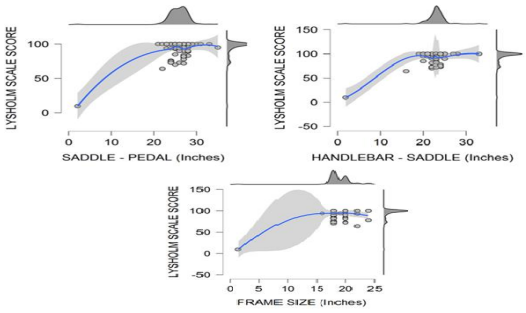

Figure 4: Scatter plot showing the relationship of the Lysholm score with the saddle-pedal and the handlebar-saddle distance and frame size

Further, a strong negative correlation was observed between the Lysholm score and right knee pain (r = -0.561, p > 0.01), and the weak negative association was also observed between the Lysholm score and left knee pain (r = -0.563, p > 0.05) (Table 1).

Table 1: Correlation between outcome variables and the Lysholm score

Variables		Lysholm score
Saddle-pedal distance	r	+ 0.091
	P value	0.370
Handlebar-saddle distance	r	+ 0.148
	P value	0.141
Frame size	r	- 0.089
	P value	0.376
Right knee pain	r	- 0.561
	P value	
Left knee pain	r	- 0.563
	P value	
Height	r	+ 0.047
	P value	0.643
Weight	r	- 0.048
	P value	0.635
BMI	r	- 0.066
	P value	0.511
Age	r	- 0.182
	P value	0.07

*r = Pearson's coefficient; p is the level of significance

The scatter plot indicated the cluster formation showing more population density of the VAS score pertaining to the right and left knee at the dipping point with an increase in the Lysholm score. In other words, there was a decrease in VAS scores for the right knee pain with an increasing Lysholm score (Figure 5).

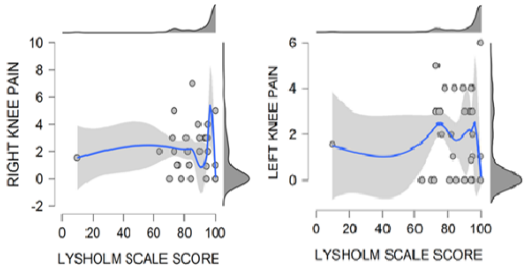

Figure 5: Scatter plot showing the relationship of the Lysholm score with the right knee pain, left knee pain and frame size

Negligible association of height with the Lysholm score was observed (r = +0.047, p = 0.643), but it was seen that taller riders (175 cm ≥) had significantly less or no pain. Negligible association of weight with the Lysholm score was observed (r = - 0.048, p = 0.635). A weak negative association was found between age and the Lysholm score (r = -0.182, p = 0.07). A weak negative association was found between BMI and the Lysholm score (r = -0.066, p = 0.511) (Table 1).

There was no fixed pattern spotted between weight and the Lysholm score. Weight ranging between 50-100 kg

shows the best Lysholm score. There was no fixed pattern observed between BMI and the Lysholm score. BMI ranging between 20-35 kg/m² has the highest Lysholm score. However, there was no fixed pattern observed between age and the Lysholm score. Cyclists between the ages of 18-25 years demonstrated to have the best Lysholm score. After 25 years of age, a slight negative correlation can be seen, i.e., as the age is increasing, the Lysholm score is decreasing (Figure 6).

DISCUSSION

Knee pain is prevalent among cyclists who participate in strenuous activities. With the increase in pedalling time, injuries encountered during cycling have become very common. A saddle height that is not appropriately adjusted can lead to knee injury and lower back pain. Low or high saddle heights vary the knee angle, which in turn affects the amount of mechanical work and effectiveness of pedalling. By optimising the knee angle, a properly adjusted seat height helps minimise injury while also improving rider economy and performance. According to Wanich et al. (2007), appropriate bicycle geometry and saddle height are important predictors for cyclists. Approximately 38% of the participating subjects experienced knee pain.

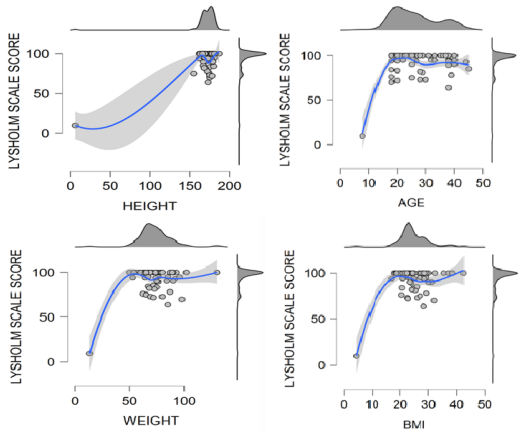

Figure 6: Scatter plot showing the relationship of the Lysholm score with height, weight, BMI, and age

Negligible association of height and weight with the Lysholm score was found. Less incidence of knee pain in taller cyclists cannot be explained by the obtained data. This will be taken into consideration for the design of the next research project. A weak negative association between the frame size and the Lysholm score was seen; however, due to the small number of subjects, we cannot draw a conclusion for it. Similarly, a weak negative association was observed between age and BMI with the Lysholm score.

We also tried to analyse the effect of legwork on knee pain in cyclists. With the current set of data, it seems that there is no clear association between leg workout and knee pain in cyclists. With inclusion of more data, we may be able to establish an association between the two. Another method to search for improper bicycle adjustment among the cyclists was via checking inseam length. Subjects were checked for their groin relation with respect to the crossbar. 61% of the subjects had no gap between their groin region and crossbar, 5% of the subjects had more than a 4-inch gap between their groin region and the crossbar indicating an improper inseam length. Only 33.3% of the subjects had the right gap between their groin region and crossbar.

A strong negative correlation was seen between knee pain (VAS scores) and the Lysholm score ($r = -0.561$ for right and $r = -0.563$ for left). It signifies that the higher the Lysholm score is, the lower the knee pain is among cyclists. In addition, it validates the reliability of the use of the Lysholm score for this research.

As per study conducted by Ashraf et al. (2010), bicycle adjustments have a direct impact on the incidence of overuse injuries in the competitive mountain bike cyclist. Based on the obtained data, we calculated the sample of 100 riders in total in which significant results were expected. According to the observations, inappropriate saddle to pedal distance as well as handlebar to saddle distance was found among subjects.

In this research study, a positive correlation between bicycle geometry and the Lysholm score was found. The saddle to pedal distance has a positive correlation with the Lysholm score ($r = +0.091$, $p = 0.370$). Similarly the handlebar to saddle distance has a positive correlation with the Lysholm score ($r = +0.148$, $p = 0.141$). Though the correlation values obtained are statistically insignificant, they definitely provide a basis to support the alternate hypothesis, i.e., bicycle geometry/adjustments has an impact on incidence of knee pain and injuries in cyclists. It was observed that cyclists with the properly adjusted saddle to pedal distance and handlebar to saddle distance had a lower incidence of knee pain.

It should be mentioned that the small number of subjects is a limiting factor of our study, which has influenced the correlation. In addition, it was observed that a majority of the total subjects were not aware about the right bicycle adjustments as well as choosing the right frame size according to their height.

LIMITATIONS OF THE STUDY

1. The sample size included was small, and therefore the results may not reflect the true population.

2. A symmetrical set of data/observations were available; more sets of observations or variety of observations are required to produce a more significant correlation.

3. Most observations lie at an age between 18 to 27 years.

FURTHER SCOPE OF THE STUDY

1. Inclusion of saddle inclination/saddle tilt can also help us learn the impact of bicycle geometry on the Lysholm Score.

2. Inclusion of more subjects of a higher age group (30 or above) can help us understand the impact of bicycle adjustment on knee pain in cyclists.

3. The inclusion of a young healthy female cyclist population can also help us learn the impact of bicycle geometry on the incidence of knee pain and injuries.

4. Here, the Lysholm Scale has been used; if we use a scale which further evaluates different sets of parameters related to cyclists and knee pain more comprehensively, we can establish a more significant relationship between bicycle geometry and knee pain in young healthy adult cyclists.

5. A similar kind of study can be done in the buttocks, lumbar spine, wrist, and finger regions.

CONCLUSION

Cycling seems to have a high potential to cause overuse injuries in young healthy adult male cyclists. A significant number of knee pain incidence was reported, which correlated with an inappropriate adjusted bicycle. More detailed conclusions cannot be drawn at this point due to the small study group. Though the present set of data produces a slight positive relationship between the saddle to pedal distance and the handlebar to saddle distance with the Lysholm score, it provides a basis to support the alternate hypothesis, i.e., "there is a significant correlation between the Lysholm score (knee) and bicycle geometry in young healthy adult male cyclists" as well as highlights the need for a comprehensive study on this.

Conflict of Interest: There were no conflicts of interest involving the researchers' personal or institutional interests in this work.

Source of Funding: Self

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POVEZANOST IZMEĐU GEOMETRIJE BICIKLA I VRIJEDNOSTI LYSHOLM BODOVNE SKALE (KOLJENO) KOD MLADIH I ZDRAVIH BICIKLISTA

Cilj: Utvrditi povezanost između geometrije bicikla i vrijednosti Lysholm bodovne skale (koljeno) kod mladih i zdravih biciklista. Dizajn: Usporedna studija. Mjesto: Regija Delhi/teritorij glavnog grada. Učesnici: Stotinu biciklista je uključeno u studiju na osnovu kriterija za odabir i isključenje. Detalji koji se odnose na protokol, uključujući i koristi, ciljeve i svrhu studije, su opisani učesnicima te su nakon toga, ukoliko zadovoljavaju uslove za učešće, morali ispuniti obrazac za pristanak na učešće u studiji. Glavne mjere ishoda: Uzeti su demografski podaci o ispitanicima, tj. ime i prezime, dob, visina i težina. Nakon toga, izmjerena je i zabilježena udaljenost između sjedišta i pedala kao i udaljenost između upravljača i sjedišta koristeći mjernu traku. Ispunjeni su dodatni obrasci za procjenu. Rezultati: Nije pronađena statistički značajna povezanost između udaljenosti sjedišta od pedala i vrijednosti Lysholm bodovne skale. Također, nije pronađena povezanost između udaljenosti upravljača od pedala i vrijednosti Lysholm bodovne skale, a koja je bila statistički značajna. Zaključak: Iako trenutni podaci ukazuju na neznatnu pozitivnu vezu između udaljenosti sjedišta od pedala i udaljenosti upravljača od pedala sa vrijednostima Lysholm bodovne skale, oni pružaju osnovu za podršku alternativne hipoteze, tj. "značajna povezanost postoji između vrijednosti Lysholm bodovne skale (koljeno) i geometrije bicikla kod mladih i zdravih biciklista", kao i naglašavaju potrebu za sveobuhvatnom studijom koja će se baviti ovom tematikom.

Ključne riječi: geometrija bicikla, Lysholm bodovna skala, udaljenost između sjedišta i pedala, udaljenost između upravljača i sjedišta, biciklist

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THE EFFICIENCY OF MASTERING AN OBSTACLE COURSE IN FEMALE STUDENTS ENROLLED IN TWO DIFFERENT STUDY PROGRAMMES

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ABSTRACT

The basic aim of this paper was to determine the efficiency of mastering an obstacle course in female students of the University of Zagreb, Faculty of Teacher Education. The study involved 45 female students - 24 female students enrolled in Early Childhood and Preschool Education studies and 21 female students enrolled in Teacher Education studies. The length of the obstacle course was 40 metres. It consisted of a total of seven motor tasks whose effective mastering required speed, coordination, strength, flexibility, and lateral agility. The results showed that, on average, female preschool teachers achieved better results on the obstacle course, i.e., they were faster than female primary school teachers by 3.94 seconds. The Mann-Whitney U test showed no significant differences in heart rate values, while significant differences between groups were confirmed in the time necessary to master the obstacle course in favour of Early Childhood and Preschool Education students.

Keywords: exercise efficiency, motor skills, heart rate

INTRODUCTION

An obstacle course is a remarkably "rewarding" methodical and organisational form which can be used throughout the entire educational process from kindergarten (Lorger, 2014; Tomac–Rojčević & Vrhoc, 2007), elementary school (Lovrić, Jelaska, & Bilić, 2015; Žuvela, Božanić, & Miletić, 2011; Lorger, 2009), to student age (Lorger, Kunješić Sušilović, & Hraski, 2017; Lorger, Kunješić, & Jenko Miholić, 2016; Lorger, Hraski, & Kunješić, 2012). An obstacle course as a methodical and organisational form can be used in sports schools (Marinković, Pavlović, Koroljev, Dimitrić, & Bogdanovski, 2016). The arrangement and placement of the obstacles within the obstacle course is very flexible and under the jurisdiction of an educator, teacher or professor. It is especially important that all motor tasks within the obstacle course are selected according to the capabilities of children and students, as well as exceptionally well-studied and trained to the level of automatisation by the participants of the obstacle course to ensure that the undertaking of the obstacle course is fluent and safe. Obstacle courses may differ in their structure according to the desired goal of the course's completion. Examples of obstacle courses intended for acquiring the motor knowledge of mastering space, obstacles, resistance and object manipulation can be found within literature (Žuvela, Božanić, & Miletić, 2011), as well as obstacle courses which can be used in various situations (Slačanac, Oreški, & Lipovac, 2012). The main point of this paper is the comparison of obstacle course mastering efficiency between groups of students of the Faculty of Teacher Education. The structure of the obstacle course contains the completion of tasks which require strength, flexibility, coordination, speed, and agility; so, the fundamental purpose is to determine the efficiency of mastering the obstacle course among the mentioned students. Sample size Sample size

RESEARCH METHODOLOGY

Sample size

Forty-five female students enrolled at the Faculty of Teacher Education, University of Zagreb, participated in the measurements. Twenty-four female students attend the Early and Preschool Education studies, and twenty-one students attend Teacher Education studies.

The sample of variables

A forty metres long obstacle course was set up in the gym. It was composed of seven motor tasks which had to be effectively completed and which required speed, coordination, strength, flexibility, and lateral agility.

The obstacle course was composed of the following tasks:

1. three double-leg jumps in a row inside and outside the three hoops placed on the floor without space among them

2. crawling under three low hurdles placed 1 metre apart

3. pulling yourself lying down on the stomach on the Swedish bench

4. running between 3 cones placed 1.5 metres apart

5. rolling around the longitudinal axis with outstretched body

6. lateral skips through floor ladders

7. 900 turn and jump in the hoop placed on the floor

Statistical analysis

The analysis and data processing was done using the computer program 13.4 with the following statistical parameters displayed. The basic descriptive parameters for the purpose of this research were:

- arithmetic mean (M)
- median (Mdn)
- minimum (Min) and maximum (Max) value
- standard deviation (SD)

Normality of distribution was tested with the Kolmogorov - Smirnov test (K-S), with a 0.05 level of significance. The Mann-Whitney U test had been used to determine the significance of differences between the groups, considering the number of participants.
Procedure

The measurement was conducted during the regular Physical Education classes in Zagreb at the Faculty of Teacher Education. After the introductory and preparatory part of the class, in the main "A" part, the female students went over the obstacle course several times over 2 minutes to reduce motor learning results to the achieved values. The obstacle course was measured afterwards. A single obstacle course measurement was performed. If the respondent made a larger error at the very beginning of the measurement, she could repeat the performance in full. The measurement was performed by the author who is also a teacher at the mentioned Physical Education class.

RESULTS

Display of the results of descriptive statistics for the whole sample and for individual groups of respondents (table 1).

Table 1 : Descriptive indicators of measurement results

Variables	M Entire sample	Min	Max	SD	K – S p >
Obstacle course start HR	124.27	72.00	162.00	26.34	0.20
Obstacle course end HR	172.93	102.00	216.00	20.03	0.20
Time achieved	30.05	22.00	44.90	5.04	0.20
Variables	M Educators	Min	Max	SD	K – S p
Obstacle course start HR	117.75	72.00	162.00	30.11	p > .20
Obstacle course end HR	168.50	102.00	216.00	22.93	p > .20
Time achieved	28.26	22.00	40.90	4.57	p > .20

Variables	M Teachers	Min	Max	SD	K – S p
Obstacle course start HR	131.71	93.00	162.00	19.37	p > .20
Obstacle course end HR	178.00	144.00	216.00	15.10	p > .20
Time achieved	32.10	26.00	44.90	4.87	p > .20

Legend: heart rate (HR), value of arithmetic means (M), average minimum (Min) and maximum (Max) result value, average value of standard deviations (SD), result distribution normality (K - S)

The analysis of the results achieved by the entire sample reveals that the average heart rate differs significantly at the start and at the end of the obstacles course. It is therefore assumed that the differences in heart rate values will be statistically significant. The average time of mastering the obstacle course across the entire sample was 30.05 seconds. Further analysis shows that the female students of the Early and Preschool Education studies (hereafter referred to as: RP00) at the start of the obstacle course had lower heart rate values, compared to the whole sample, but also compared to the values of female students attending Teacher studies (hereafter referred to as: US). The difference between starting and ending pulse values in RP00 female students was 50.75 beats, while in the female students of Teacher Education Study, it was 46.30 beats. The ranges between the minimum and maximum results are high values, which is visible by the standard deviations shown. The greatest dispersion of results is observed in the group of RP00 female students at the start of the obstacle course (30.11), and it is greater than the values obtained for the entire sample. It indicates that the results of RP00 female students had a greater impact on the dispersion of the results of the entire sample of respondents. A more detailed analysis shows that the average maximum values of the results at the end of the obstacle course are identical in both groups, but the "female educators" achieved a better result on average, that is, they were 3.94 seconds faster than "female teachers".

Table 2 : Mann-Whitney U test results: RP00 and US students

Variables	U	Z	p-value
Obstacle course start HR	184.50	-1.52	0.13
Obstacle course start HR	183.00	-1.56	0.12
Time achieved	134.00	-2.67	0.01

Legend: Mann-Whitney U test results (U), standardised values (Z), significance of differences (p)

The significance of the differences between the groups was verified by the Mann-Whitney U test. Although it could have been expected that the differences in heart rate (HR) values at the beginning and at the end of performance would be significant given their numerical values, it was not the case. The significance of the differences between groups was confirmed only in the time required to complete the obstacle course. The results of the aforementioned test showed that RP00 students completed the obstacle course faster, and the difference in the time required to complete it is statistically significant.

DISCUSSION

An insight into the results of descriptive statistics shows that, in both groups of respondents, the effects of mastering the obstacle course content were similar, i.e., that the increase in heart rate at the end of the obstacle course performance was approximate. Accordingly, it can be said that the obstacle course contents produced a similar load level for both groups. A deeper analysis shows that the female students of Early and Preschool Education had slightly lower heart rate values at the beginning and end of the performance, compared to the female students of Teacher Education, but they mastered the obstacle course in a shorter time. This is an indication of their better level of fitness, when compared to the group of female students of Teacher Education because the heart rate values were lower during the shorter time period needed for completing the obstacle course. In the Lorger, Hraski and Kunješić paper (2012), on a sample of female students of Teacher Education, in which an obstacle course (which by its structure was also a "motor" obstacle course) was used as a means of work intensification in the main "A" part of the lesson, pulse values ranged from 111.08 to 134.33 beats per minute, and in the main "B" part, they ranged from 116.78 to 174.59 beats per minute. Comparing the results, very similar heart rate values are observed. In this research, female students of Teacher Education had slightly higher starting (HR = 131.71) and final (HR = 178.00) heart rate values than in the previous research (HR = 116.78; HR = 174.59). The results of heart rate values obtained in this research are also very similar to the results of research conducted by Džibrić, Ahmić and Pajić from 2017, which was conducted on female Teacher Education students from the University of Tuzla. From the above, it can be concluded that the results of overcoming the obstacle course with similar structures on different groups of respondents are similar. This indicates that this is an organisational form of work that can be highly intensive according to the level of workload because the competitive moment is present during the measurement of results. Namely, measuring the results of the obstacle course encourages the personal motivation of every participant to achieve a result better than the previous one, which is the essence of work in the field of physical and health education - personal positive transformation of the anthropological status.

CONCLUSION

As an organisational form of work, the obstacle course is often used in the process of education from kindergarten to adulthood. In this study, although expected, no significant differences in heart rate values were confirmed between the female students of Early and Preschool Education and female students of Teacher Education; so, it can be said that the contents of the obstacle course were at a similar level of load for both groups. A statistically significant difference between the groups was confirmed only in the time required to master the obstacle course in favour of the female students of Early and Preschool Education studies, which shows a higher level of their fitness preparation.

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EFIKASNOST SAVLADAVANJA POLIGONA PREPREKA KOD STUDENTICA RAZLIČITIH STUDIJSKIH PROGRAMA

Temeljni cilj rada bio je utvrditi efikasnost savladavanja poligona prepreka kod studentica Sveučilišta u Zagrebu na Učiteljskom fakultetu. U istraživanju je učestvovalo 45 studentica, od čega 24 studentice koje pohađaju Studij ranog i predškolskog odgoja i 21 studentica koja pohađa Učiteljski studij. Dužina poligona iznosila je 40 metara. On je sadržavao 7 motoričkih zadataka za čije je efikasno savladavanje bila potrebna sposobnost brzine, koordinacije, snage, fleksibilnosti i bočne agilnosti. Rezultati su pokazali da su ,,odgajateljice' u prosjeku postigle bolji rezultat na kraju poligona, odnosno da su za 3,94 sekunde bile brže od ,,učiteljica''. Mann Whitney U test nije pokazao značajne razlike u vrijednostima srčane frekvencije, a značajne razlike između grupa su potvrđene u vremenu potrebnom za savladavanje poligona u korist studentica Ranog i predškolskog odgoja i obrazovanja.

Ključne riječi: efikasnost vježbanja, motoričke sposobnosti, srčana frekvencija

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ANALYSIS OF DIFFERENCES IN MORPHOLOGICAL CHARACTERISTICS BASED ON THE LEVEL OF FUNCTIONAL ABILITY IN STUDENTS OF THE UNIVERSITY OF BIHAĆ

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ABSTRACT

This research aimed to determine the existence of possible differences in certain morphological characteristics observed in the context of the subjects' level of aerobic capacity. The research was conducted as a transversal empirical study. The research sample consisted of a total of 125 students (both sexes) from the University of Bihać. Subsampling was performed on the basis of the measured values of functional abilities detected by the field test for aerobic capacity assessment - BEEP test (Copyright © Loughborough University, 2002), namely: (1) a group of subjects with higher values of aerobic capacity (N = 59) and (2) a group of subjects with lower values of aerobic capacity (N = 66). A battery of 10 tests, used in a number of recent studies (Skender, 2008; Skender et al., 2021), has been used to assess the characteristics of subjects in the morphological space. The morphological space variables include: body height (AVIS), arm span (ARAR), sitting height (ASVIS), lateral abdominal skinfold (AKNTSUB), subscapular skinfold (AKNSK), upper arm skinfold (AKNNADL), upper arm circumference (AONADL), thigh circumference (AONADK), abdominal circumference (AOTRB), and body weight (AMAS).

Keywords: morphological characteristics, functional abilities, students

INTRODUCTION

Numerous recent scientific studies have shown the link between physical activity and health. The results support the positive impact of physical activity and the negative impact of a sedentary lifestyle on health (Mišigoj-Duraković, 1999). In their study, Skender et al. (2021) reported results showing that morphological characteristics affect poor posture because, in most case, there were certain anomalies in students who had increased measures in morphological characteristics. Morphological characteristics are responsible for the growth and development of the body, for the dynamics of growth and development, and for the characteristics of body structure. They refer to the structure and shape of a person, and they consist of the following dimensions: longitudinal dimensionality of the skeleton, transverse dimensionality of the skeleton, volume (circumference and body weight), and subcutaneous adipose tissue (Žderić, 2010). Morphological anthropometry can be defined as a method related to the study and measurement of the human body and the processing of the obtained

measurement results (Mišigoj - Duraković, 2008). Morphological anthropometry is used in various kinesiological areas in which measurements are performed in order to monitor the growth and development of youth (Mišigoj - Duraković, 2008). Morphological characteristics are conditioned by the genetic code, but the training process and diet can influence the growth and development of muscle mass, reduction of subcutaneous fat and sports activities. Based on this research, we can conclude that the morphological characteristics of body circumference, subcutaneous adipose tissue and body weight significantly influenced the development of poor posture and deformity of the body. The rate of growth and development accelerates or slows down depending on age, and thereby body parts develop at different speed (Milanović, 2010). Kinesiological inactivity also negatively affects posture and morphological development. Continuous use of physical activity is of great importance in maintaining human health (Prskalo & Sporiš, 2016). Functional abilities refer to the efficient ability of the human body to carry oxygen that supplies muscles with the amount of energy needed for intensive work and the effectiveness of anaerobic energy capacities, which are responsible for the successful performance of certain kinesiological activities of high strength and intensity (Milanović, 2010). We can influence the development of functional abilities during the entire life period, and influence the regulation of functional abilities through continuous exercise (Findak, 2001). The research is aimed at identifying the existence of possible differences in certain morphological characteristics observed in the context of the subjects' level of aerobic capacity.

METHOD

The research was conducted as a transversal empirical study. The research sample consisted of a total of 125 students (both sexes) from the University of Bihać. Subsampling was performed on the basis of the measured values of functional abilities detected by the field test for aerobic capacity assessment - BEEP test (Copyright © Loughborough University, 2002) as follows: (1) group of subjects with higher values of aerobic capacity (N = 59) and (2) a group of subjects with lower levels of aerobic capacity (N = 66) (Table 2).

A battery of 10 tests, used in a number of recent studies (Skender, 2008; Skender et al., 2021), was used to assess the characteristics of subjects in the morphological space. The morphological space variables included: body height (AVIS), arm span (ARAR), sitting height (ASVIS), lateral abdominal skinfold (AKNTSUB), subscapular skinfold (AKNSK), upper arm skinfold (AKNNADL), upper arm circumference (AONADL), thigh circumference (AONADK), abdominal circumference (AOTRB), and body weight (AMAS).

Descriptive and comparative statistical procedures were used to process and interpret empirical data. Central and dispersion parameters (Mean, Std. Deviation, Std. Error Mean) were calculated from the space of descriptive statistics, while in the space of comparative statistics, the following procedures were predominantly used: t-test and canonical discriminant analysis.

RESULTS

The results of the analysis of empirical data, which was aimed at identifying possible differences in the subjects' morphological space and in the context of the level of their functional abilities (aerobic capacity values assessed by BEEP test), were obtained using the t-test and canonical discriminant analysis.

Previously, a correlation matrix of variables from the morphological space (as a set of predictors) and indicators of functional abilities (FSBEEPT as dependent variables) was created, which showed the existence of an appropriate acceptable level of strength and direction of the linear relationship between the observed variables (Table 1). Thus, adequate preconditions were created for further analysis of empirical data.

Table 1 : Correlation matrix of the observed variables

Variable	VIS	ARAR	ASVIS	AKNTSUB	AKNSK	AKNNADL	AONADL	AONADK	AOTRB	FSBEEPT	AMAS
AVIS	1										
ARAR	.919**	1									
ASVIS	.670**	.534**	1								
AKNTSUB	-.027	-.041	.099	1							
AKNSK	.167	.143	.147	.751**	1						
AKNNADL	-.209*	-.236**	-.078	.745**	.722**	1					
AONADL	.383**	.376**	.299**	.634**	.666**	.557**	1				
AONADK	.290**	.231**	.160	.639**	.743**	.644**	.783**	1			
AOTRB	.515**	.504**	.386**	.671**	.705**	.424**	.810**	.741**	1		
FSBEEPT	.286**	.364**	.073	-.490**	-.405**	-.582**	-.035	-.280**	-.054	1	
AMAS	.567**	.529**	.374**	.518**	.610**	.340**	.744**	.735**	.854**	-.024	1

The values of the arithmetic means (Mean) for the subsamples were also calculated. Subsampling was performed in relation to the determined values of the BEEP test: Group 1 - students with higher values of aerobic capacity (N = 59) and Group 2 - students with the determined lower levels of aerobic capacity (N = 66) (Table 2).

Table 2 : Descriptive parameters of the subsamples

Variable	GROUP	N	Mean	*Std. Dev.*	*Std. Err. Mean*
AVIS	Better AC	59	168.2966	*8.24523*	*1.07344*
	Weaker AC	66	168.0591	*8.69691*	*1.07052*
ARAR	Better AC	59	168.6017	*8.93838*	*1.16368*
	Weaker AC	66	166.8561	*9.36547*	*1.15281*
ASVIS	Better AC	59	88.8746	*4.76607*	*.62049*
	Weaker AC	66	89.5848	*4.65876*	*.57345*
AKNTSUB	Better AC	59	1.6271	*.65255*	*.08495*
	Weaker AC	66	2.2803	*.83205*	*.10242*
AKNSK	Better AC	59	1.1142	*.34118*	*.04442*
	Weaker AC	66	1.6418	*.66411*	*.08175*
AKNNADL	Better AC	59	1.4054	*.49804*	*.06484*
	Weaker AC	66	2.0715	*.68248*	*.08401*
AONADL	Better AC	59	27.5898	*4.02898*	*.52453*
	Weaker AC	66	29.5485	*3.83952*	*.47261*
AONADK	Better AC	59	53.9983	*4.79045*	*.62366*
	Weaker AC	66	58.5258	*6.02633*	*.74179*
AOTRB	Better AC	59	73.6797	*9.05911*	*1.17940*
	Weaker AC	66	78.3621	*10.16089*	*1.25072*
AMAS	Better AC	59	62.9373	*12.95286*	*1.68632*
	Weaker AC	66	69.1106	*13.68838*	*1.68492*

Quantitative indicators of t-test values show that, between the subsamples, in most of the measured morphological dimensions (as variables of the morphological space), there are statistically significant differences in the determined mean values ($p < 0.050$). Variables for which no differences were found at a statistically significant level are: height (AVIS; Sig. = 0.876), arm span (ARAR; Sig. = 0.290) and sitting height (ASVIS; Sig. = 0.402). For all other morphological dimensions included in the study, there are significant differences in their mean values as follows: lateral abdominal skinfold (AKNTSUB; Sig. = 0.000), subscapular skinfold (AKNSK; Sig. = 0.000), upper arm skinfold (AKNNADL; Sig. = 0.000), upper arm circumference (AONADL; Sig. = 0.006), thigh circumference (AONADK; Sig. = 0.000), abdominal circumference (AOTRB; Sig. = 0.007), and body weight (AMAS; Sig. = 0.011) (Table 3).

Table 3 : Significance of differences in arithmetic means of the observed variables from the morphological space

Variable	t	df	Sig.	Mean Diff.	Std. Error Diff.
AVIS	.156	123	.876	.23752	1.52057
ARAR	1.063	123	.290	1.74563	1.64234
ASVIS	-.842	123	.402	-.71027	.84381
AKNTSUB	-4.909	121.014	**.000**	-.65318	.13307
AKNSK	-5.671	99.342	**.000**	-.52758	.09303
AKNNADL	-6.277	118.415	**.000**	-.66609	.10612
AONADL	-2.774	119.892	**.006**	-1.95865	.70604
AONADK	-4.672	121.394	**.000**	-4.52745	.96913
AOTRB	-2.724	123.000	**.007**	-4.68246	1.71909
AMAS	-2.590	122.590	**.011**	-6.17332	2.38383

The results obtained using the discriminant analysis procedure show that one significant discriminant factor was singled out, which represents a common variance of the difference of arithmetic means in the compared groups of subjects (two subsamples classified according to the criterion of results achieved on the test of functional abilities - better values and lower values). The canonical correlation coefficient (0.554) corresponds with the acceptable values of the discriminant analysis of 55% between subsampled groups of subjects. Additionally, the values of discriminant strength (Wilks' lambda: 0.694), tested by the values of Bartlett's chi-square test (chi-square: 43.175) and based on the coefficient of significance, show that the differences are at the level of statistical significance (Sig. = 0.000) (Table 4). This leads to the conclusion that the results of the test battery for the assessment of morphological space may have value consequences in the context of the identified aerobic capacity of the subjects.

Table 4 : Significance of the isolated discriminant function

Disc. Func.	Eigenvalue	Can. correlation	Wilks' lambda	Chi-square	df	Sig.
1	.442	.554	.694	43.175	10	.000

The created matrix of the structure of morphological variables, which are related to the context of the subsamples' functional abilities, show the contribution of each morphological dimension to the identified discriminant function. The variable of the upper arm skinfold (.837) has the largest contribution, followed by the subscapular skinfold (.744), and the variable of the lateral abdominal skinfold (.657), i.e., the thigh circumference (.626). Conditionally,

The created matrix of the structure of morphological variables, which are related to the context of the subsamples' functional abilities, show the contribution of each morphological dimension to the identified discriminant function. The variable of the upper arm skinfold (.837) has the largest contribution, followed by the subscapular skinfold (.744), and the variable of the lateral abdominal skinfold (.657), i.e., the thigh circumference (.626). Conditionally,

Table 5 : Hierarchical structure of the isolated discriminant function of morphological tests

Variables	Function
AKNNADL	.837
AKNSK	.744
AKNTSUB	.657
AONADK	.626
AONADL	.377
AOTRB	.367
AMAS	.350
ARAR	-.144
ASVIS	.114
AVIS	-.021

The discriminant function of the centroid pertaining to the measured values of the arithmetic means for all the observed variables in the morphological space is: -0.697 (group with better AC) and 0.623 (group with weaker AC). The identified values of the measurement centroids, tested through the significance of the discriminant function, draw attention to their distance within the statistical significance. The subjects with the determined better result of aerobic capacity are situated on the negative pole of the discriminant function, while the subjects who are classified in the subsample as those having lower results of aerobic capacity are positioned on the positive pole (Table 6).

Table 6 : Position of the centroid groups on the discriminant function

GROUP	Function
Better AC	-.697
Weaker AC	.623

DISCUSSION AND CONCLUSION

The aim of this research was to identify the existence of possible differences in certain morphological characteristics observed in the context of aerobic capacity levels in two groups of subjects from the University of Bihać. The groups were formed based on better and worse results in performing the BEEP test. This is a classic test of functional abilities that assesses the anaerobic - aerobic abilities of students. Based on this, we estimated their physical activities, since it is the physical activity that develops functional abilities. This study comprised a test that included morphological space variables. Quantitative indicators of t-test values showed that there were statistically significant differences between the subsamples in most of the measured morphological dimensions (as variables of morphological space) ($p < 0.050$). Variables for which no differences were found at a statistically significant level are: height (AVIS; Sig. = 0.876), arm span (ARAR; Sig. = 0.290) and sitting height (ASVIS; Sig. = 0.402). For all other morphological dimensions included in the study, there are significant differences in their mean values as follows: lateral abdominal skinfold (AKNTSUB; Sig. = 0.000), subscapular skinfold (AKNSK; Sig. = 0.000), upper arm skinfold (AKNNADL; Sig. = 0.000), upper arm circumference (AONADL; Sig. = 0.006), thigh circumference (AONADK; Sig. = 0.000), abdominal circumference (AOTRB; Sig. = 0.007), and body weight (AMAS; Sig. = 0.011). Skender et al. (2021) also found a high level of association between BMI and the level of functional abilities of the BEEP test. Based on all this, we can say that the level of functional abilities can be significantly increased by increasing physical activity, especially in the student population where a sedentary lifestyle predominates due to college obligations, and work should be done to improve conditions for more active sports, greater physical activity and better organisation of physical exercise at colleges. Information on the number, structure and relations of a person's morphological dimensions is far more important for scientific research, since they are the result of physiological functioning and regulation of human biological growth and development

(Bala, 2000). The created matrix of the structure of morphological variables, which are related to the context of the subsamples' functional abilities, show the contribution of each morphological dimension to the identified discriminant function. The variable of the upper arm skinfold (.837) has the largest contribution, followed by the subscapular skinfold (.744), and the variable of the lateral abdominal skinfold (.657), i.e., the thigh circumference (.626). Conditionally, the second level, contributing to the discriminant function, with significantly lower coefficient values gives variables: upper arm circumference (.377), abdominal circumference (.367) and body weight (.350). The lowest values of the coefficient (as, conditionally, the third level) are present in the variables: arm span (-.144), sitting height (.114) and body height (-.021). In our study, we confirmed that insufficient physical activity of students affects morphological characteristics, and this clearly shows that the decrease in aerobic capacity caused by lower levels of movement in students can significantly affect the student population. It should be noted that the research was conducted during the COVID-19 pandemic, so we assume that it probably affected the level of student movement, and negatively affected physical activity and the morphological characteristics of students, which was confirmed in the study (Sabic, Skender, et al., 2021). In their research (Živanović, Branković, & Pelemiš, 2017; Bala, Jakšić, & Popović, 2009; Bokor, Horvat, & Hraski, 2016), based on the results, the researchers concluded that girls had a higher amount of subcutaneous tissue in the abdomen, compared to boys, while in their research, Pelemiš, Pelemiš, and Lalić (2015) as well as Martinović, Pelemiš, Branković, and Mitrović (2012) came to the conclusion that girls also had more subcutaneous adipose tissue in the back and upper arms, and these results were also closely related to natural forms of leisure movement, since boys are more active than girls. Physical activities during the development and growth of the organism itself have a positive effect and cause changes in the morphological status and motor skills (Mišigoj-Duraković, 2008). Morphological characteristics, in addition to affecting a more successful manifestation of functional abilities, should be one of the conditions for the appearance of students who need to work during certain ages before their appearance and attitude should be presented as an example. Of course, the results obtained should also improve practice. Given the existence of environmental influence on the development of morphological characteristics and functional abilities, the data provided by this research will help the environment as an influential factor in development.

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ANALIZA RAZLIKA U MORFOLOŠKIM KARAKTERISTIKAMA NA OSNOVU NIVOA FUNKCIONALNE SPOSOBNOSTI STUDENATA UNIVERZITETA U BIHAĆU

Ovo istraživanje je imalo za cilj utvrditi postojanje mogućih razlika u pojedinim morfološkim karakteristikama posmatranim kroz kontekst nivoa aerobnog kapaciteta ispitanika. Istraživanje je realizovano kao transverzalna empirijska studija. Uzorak istraživanja činilo je ukupno 125 studenata (oba spola) sa Univerziteta u Bihaću. Poduzorkovanje je izvršeno na osnovu izmjerenih vrijednosti funkcionalnih sposobnosti detektovanih terenskim testom za procjenu aerobnog kapaciteta - BEEP testom (Autorska prava Loughborough Univerziteta, 2002), i to: (1) grupa ispitanika sa višim vrijednostima aerobnog kapaciteta (N = 59) i (2) grupa ispitanika sa nižim vrijednostima aerobnog kapaciteta (N = 66). Baterija od 10 testova korištenih u brojnim novijim studijama (Skender, 2008; Skender et al., 2021) korištena je za procjenu karakteristika subjekata u morfološkom prostoru. Varijable morfološkog prostora uključuju: tjelesnu visinu (AVIS), raspon ruku (ARAR), visinu sjedenja (ASVIS), bočni trbušni nabor (AKNTSUB), kožni nabor lopatice (AKNSK), nabor nadlaktice (AKNNADL), obim nadlaktice (AONADL), obim butina (AONADK), obim abdomena (AOTRB) i tjelesnu težinu (AMAS).

Ključne riječi: morfološke karakteristike, funkcionalne sposobnosti, studenti

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A NEW RATIONALE TO ASSESS BALANCE IN SKIERS

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ABSTRACT

Balance control is crucial for performance enhancement and in this last decade, it has become a crucial target during coaching routines with unstable equilibrium conditions. The spread of multiple approaches to evaluate balance improved the knowledge of the posture and body arrangement during the performance, when the action is complex and rapid such as skiing. The aim of this study is to evaluate skiers' balance in an ecological condition (with boots) versus a traditional way (barefoot). Twenty adolescents practicing alpine skiing, who participated in national championships, took part in this comparative study. The athletes were invited to carry out a stabilometric test lasting 30 seconds in a rest condition. They randomly carried out the test without shoes (barefoot) and with their own ski boots (boots) on a balance platform. A period of 30 minutes elapsed between the tests conditions to minimise the learning effect. The comparison of ellipse area values between barefoot and boots condition showed high significant differences in boys ($p < 0.001$, $\eta^2 = 0.574$) and in girls ($p = 0.040$, $\eta^2 = 0.177$), while the length of the COP displacement or sway did not show significant differences. The assessment with boots is different than the usual setting, whereas the athletes performed the trial in a barefoot condition, suggesting a more functional approach to training because the final performance should be considered as a holistic interrelation between the athlete, shoes, tool, technique, condition, and environment.

Keywords: balance, professional skiers, skiing, ski boots, functional evaluation

INTRODUCTION

During the standing posture, the neuromuscular system continuously performs body arrangements to maintain a standing position with a low energy cost (Gribble et al., 2007). In fact, the upright posture involves both voluntary movements and postural reflexes able to compensate the slight oscillations of the whole body (Kwon et al., 2014). This process occurs through a combination of cutaneous and kinaesthetic mechanoreceptors incorporated in the skin surface, muscles and joints to provide inputs to the central nervous system (Gribble et al., 2007; Sforza, Eid, & Ferrario, 2000).

Currently, a valid method to measure postural control is the evaluation of the centre of pressure displacement (COP) (Baldini et al., 2013; Lin et al., 2008; Pagnacco et al., 2015; Ruhe et al., 2010; Taylor et al., 2015) that is the resultant of the ground reactions and of the external forces acting on the whole body (Winter, 1990). The trajectory of the COP has therefore, in the last 10 years, captured the interest of the scientific community because it is considered a robust estimate of the centre of mass movements during daily activities (Masani et al., 2014).

In fact, recently, the COP sway has also been used to evaluate static posture (Saripalle et al., 2014), asymmetry (Gasq et al., 2014), the effects of different natural or artificial corrected dental conditions (Amaral et al., 2013; Baldini et al., 2013; Perinetti et al., 2010, 2012), and the effects of rehabilitation sessions for the recovery of balance (Freyler et al., 2014). COP sway was also assessed to evaluate the general ability in motor control (i.e., balance) among different sports athletes (Asseman et al., 2008;

Chapman, et al., 2008; Sforza et al., 2003) and after muscle fatigue (Bruniera et al., 2013).

From another point of view, balance control is crucial for performance enhancement (Latash, 2012) and in this last decade, it has become an important target during coaching routines with unstable equilibrium conditions to stimulate the deep core muscles (Schmidt & Lee; 2011).

For these reasons, the use of stabilometric systems has become functional for an objective evaluation of the COP during the evaluation of an intervention's efficacy (training, rehabilitation, orthodontic or orthopaedic) in both static and dynamic conditions.

This approach improves the knowledge of the posture and body arrangement during the performance, when the action is complex and rapid. The accuracy of balance measuring and its applicability for practical use is a challenge for device developers (Hartmann et al., 2009; Panero et al., 2018). For example, three-dimensional motion analysis systems (Merriaux et al., 2017) measure movements with a high degree of precision but are expensive, technically difficult to use, and labour intensive, and therefore not easily applicable to practical settings (Panero et al., 2018). Instead, the baropodometric platforms are commonly used in practical settings and in a laboratory, allowing technicians and researchers to decrease the preparation time of the subjects for the test (Correale et al., 2021).

Nowadays, new progress has become essential: from general to specific. Indeed, after a robust definition of tools and procedures, the new approach for a practice assessment in sport is a fit-real-life protocol. In other words, the assessment should closely tend to the real practice/action of a sport movement.

PROBLEM AND AIM

In light of this view and considering the skiing and skiers' evaluation, why do we measure the COP in barefoot condition when his performance is supported by boots?

Why do we impose unique standing "steps" when each person uses his own foot widths?

Why assess the COP (as an index of balance ability) in barefoot condition or with training-shoes when the skiers have to maintain the stance with restricted tibio-tarsal movements only in flexion and extension, and the general balance is managed with locked ankles (boots) and the movement of the COM is modulated through another tools (i.e., ski edges on snow)?

These are the questions that led us to the rationale for this pilot study that aimed to verify the COP sway differences in high-level skiers with bare feet or wearing their own boots.

METHODS

Subjects

Twenty adolescents practicing alpine skiing at a professional level and participating in national championships took part in the comparative study after their parents/legal guardians signed the informed consent to adhere to the experimental procedures. In particular, the athletes had an average ski experience of eight years with a minimum annual ski practice of 500 hours and 150 dedicated to the training condition. All of them were in the first twenty positions in the National ranking

Demographic Characteristics				
Subjects	Age (y)	Weight (Kg)	Height (cm)	BMI (Kg/m^2)
M1	12	32	135	17.56
M2	12	37	160	14.45
M3	14	50	172	16.90
M4	12	56	164	20.82
M5	11	40	140	20.41
M6	12	41	142	20.33
M7	11	28	135	15.36
M8	11	42	140	21.43
F1	16	67	168	23.74
F2	13	59	170	20.42
F3	13	46	152	19.91
F4	14	50	154	21.10
F5	13	52	160	20.31
F6	11	45	153	19.22
F7	16	63	174	20.81
F8	17	54	155	22.48
F9	17	61	163	22.96
F10	12	51	140	26.02
F11	13	50	160	19.53
F12	12	40	158	16.02

Table 1 : Anthropometric Characteristics of Skiers

Procedures

At the end of the summer training period and before the competitive season, the athletes were invited to carry out a stabilometric test lasting 30 seconds in a rest condition.

They randomly carried out the test without shoes (barefoot) and with their own ski boots (boots) on the ProKin252 platform (Tecnobody, Dalmine, Italy). A period of 30 minutes elapsed between the tests conditions to minimise the learning effect (Lovecchio et al., 2017).

Data analysis
The stabilometric platform software allows to view the COP sway measure outcomes in real time and at the end of each test. In particular, it measures the length of the COP displacement or sway (SL; mm) and the standardised ellipse area (EA, mm²) that contains 95% of the generated path. The software also provides the average speed (mm/sec) of the COP displacement, distinguishing lateral (SML; mm/sec) and antero-posterior (VAP; mm/sec) components.

Statistical analysis
Microsoft Excel was used to input all data in a stand-alone database. All data were analysed using Prism 9.0 for Mac. A paired t-test was used to elucidate the differences between subjects that complete the test barefoot or with boots for each item (SL, EA, SML, SAP), in boys, girls and both sexes. Furthermore, the percentage difference between the two conditions for both axes (SML, SAP) in boys (B), girls (G) and both sexes were also calculated. The significance level was set at 5%.

RESULTS

The comparison of EA values between barefoot and boots condition showed high significant differences in boys ($p < 0.001$, $\eta^2 = 0.574$), in girls ($p = 0.040$, $\eta^2 = 0.177$) and in the pooled group ($p < 0.001$, $\eta^2 = 0.289$), while the SL did not reveal any significant differences between groups (Figure 2): boys ($p = 0.807$, $\eta^2 = 0.004$), girls ($p = 0.565$, $\eta^2 = 0.015$) and both sexes ($p = 0.552$, $\eta^2 = 0.009$).

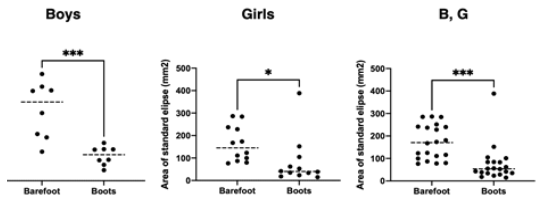

Figure 1. Comparison of the area of standard ellipse between barefoot and boots condition: B: boys; G: girls; both sexes (B, G)
Note: *** p < 0.001; *p = 0.040

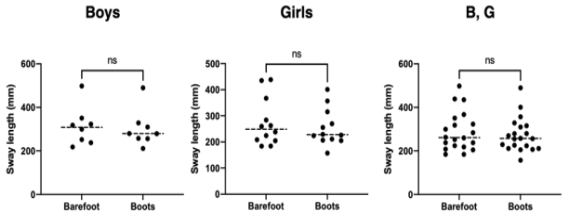

Figure 2. Comparison of the COP sway length between barefoot and boots condition. B: boys; G: girls; both sexes (B, G)

In general, the SML speed was 5.82, 5.38 and 5.56 mm/sec, respectively, for boys, girls and both sexes who performed the test barefoot. By contrast, 4.97, 4.09 and 4.44 mm/sec was measured for boys, girls and both sexes who performed the test with boots (Figure 3, upper panel).

SAP (figure 3, bottom panel) speed was 7.29, 6.14 and 6.60 mm/sec, respectively, for boys, girls and both sexes who performed the test barefoot, while 7.58, 6.47 and 6.91 mm/sec was measured in the test with boots.

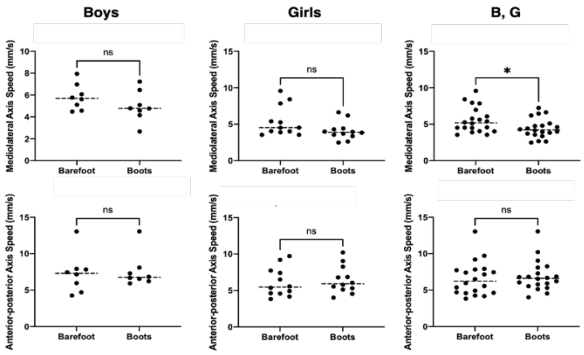

Figure 3. Comparison of mediolateral axis speed (first) and anterior-posterior axis speed between subjects that complete the test barefoot or with boots in boys, girls and both sexes (B, G)
Note: *p = 0.029

Considering the speed of COP displacement, a significant difference emerged only in the group of both sexes (B, G) ($p = 0.029$, $\eta^2 = 0.119$) and only in SML axis speed.

The SML percentage reduction overreaches 15% in boots condition in respect of the barefoot one (Figure 4).

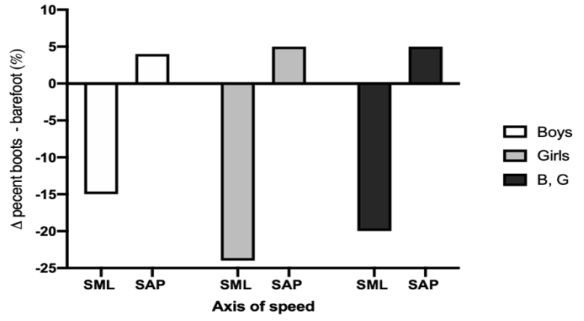

Figure 4. Percentage differences between the two conditions for both axes (SML, SAP) in boys, girls and both sexes (B, G).
Note: SML = lateral components, SAP = antero–posterior components.
Percentage difference = ((Boot - Barefoot)/Barefoot) x 100

DISCUSSION

This short comparative study sought to highlight how balance is highly discipline-specific in skiing.
Firstly, at a human level, balance is managed by an overlapping of (Wade & Jones, 1997): reflex, automated and voluntary (cortical) interventions. Thus, the synergy of the three levels of the nervous system makes it hard to study balance as a scientific assessment, mostly due to the low repeatability in long term conditions (Lovecchio et al., 2017). Furthermore, laboratory conditions usually "force" the natural stance of the subjects who immediately perceive internal forces of imbalance (Sforza et al., 2006). At the same time, scientific evaluations in cross-sectional or longitudinal studies must refer to standard procedures. For these reasons, the authors of the present study aimed to demonstrate that it is important to eliminate, as far as possible, confounding or limiting factors such as the barefoot evaluation for healthy subjects who need to know the "control system" variations in race conditions.

In light of this, our comparison between the evaluations carried out barefoot and with boots is very explanatory.

The motor control system during balancing seems to follow a very different pattern/schema (Latash, 2012). Indeed, the EA is reduced (up to 70% refracted) in the boots condition, compared to barefoot, while the SL resulted in an unchanged state. As already demonstrated after strength training protocols (Sforza et al., 2013), these results suggest that the skiers, wearing the boots, interpreted the balancing control with less amplitude but with the same SL: this appears as a movement with more micro-oscillations (improvements in frequency).

Skiers kept the speed of movement in the latero-lateral direction (Batista et al., 2014) as well as in the antero-posterior direction, which is probably their typical tendency of the race gesture.

Summarising, these results showed that the assessment with boots is different than the usual setting, whereas the athletes performed the trial in barefoot condition. Which is the correct way? In our opinion the evaluations are more in line with the race gesture or that which better simulates the body arrangement of the discipline, i.e., the use of boots. In fact, the boots condition revealed a very different gesture: effective reduced displacement and SML with a mean percentage reduction of 20% (Fig 4).

From a functional point of view, specifically for the setting of physical training, the training of balance sessions could be performed wearing boots and focusing on the AP direction.

On the other hand, it would be interesting to pay attention to the SAP movements which, with the help of a technician, could be better oriented thanks to our results. In this light, technicians should evaluate if it is always correct to block some movements when these are specific to the interpretation of a sporting gesture. Also, during the physical preparation sessions, technicians should include specific exercises with the use of the boots and with a different training stimulus.

Moreover, to better accomplish the performance enhancements, it would be appropriate to evaluate whether the design of the boots considers the functional balance (Schmidt & Lee; 2011).

According to our research, there are no studies with this aim, but it is limiting to treat the boot complex (ski/plate/binding) only as a tool to transfer forces for the maximum race performance. In fact, in physical training, the race postural attitude of ankle dorsal and plantar flexion of an athlete is altered influencing the knee flexion and the power output of the lower limbs during extension (Neumann, 2008; Winter, 1990).

Considering this view, the study of a boot should also be focused on the amelioration of balancing movements.

CONCLUSION

This new approach to evaluate athletes wearing their tool suggests a more functional approach to training because the final performance should be considered as a holistic interrelation between the athlete, shoes, tool, technique, condition, and environment.

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NOVO OBRAZLOŽENJE PROCJENE RAVNOTEŽE KOD SKIJAŠA

Kontrola ravnoteže je ključna za poboljšanje izvedbe te je u ovoj posljednjoj deceniji postala ključni cilj tokom treninga sa nestabilnim uslovima ravnoteže. Širenje višestrukih pristupa za procjenu ravnoteže je poboljšalo znanje o držanju i poravnanju tijela tokom izvedbe kada je radnja složena i brza poput skijanja. Cilj ove studije je procijeniti ravnotežu skijaša u ekološkom stanju (sa pancericama) u odnosu na tradicionalni način (bosih nogu). Dvadeset adolescenata koji se bave alpskim skijanjem, a koji su učestvovali na državnim prvenstvima, je učestvovalo u ovoj komparativnoj studiji. Sportisti su izvodili stabilometrijski test u trajanju od 30 sekundi u stanju mirovanja. Test su nasumično izvodili bez cipela (bosi) i sa vlastitim skijaškim čizmama (pancericama) na balans platformi. 30 minuta je prošlo između uslova testiranja kako bi se efekat učenja sveo na minimum. Poređenje vrijednosti površine elipse između stanja bosih nogu i sa pancericama je pokazalo visoke značajne razlike kod dječaka ($p < 0,001$, $\eta^2 = 0,574$) i kod djevojčica ($p = 0,040$, $\eta^2 = 0,177$), dok dužina pomaka COP-a ili ljuljanje nije pokazalo značajne razlike. Procjena sa pancericama je drugačija od uobičajene situacije gdje sportisti ispitivanje izvode bosih nogu što ukazuje na funkcionalniji pristup treningu jer konačnu izvedbu treba posmatrati kao holistički međuodnos između sportiste, obuće, alata, tehnike, stanja i okruženja.

Ključne riječi: ravnoteža, profesionalni skijaši, skijanje, pancerice, funkcionalna evaluacija

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POKEMON GO IN TIMES OF COVID-19: DOES IT HAVE ANY EFFECT ON PROMOTING TEENAGERS' PHYSICAL ACTIVITY?

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ABSTRACT

One of the main problems during the COVID-19 pandemic that needs to be considered is the decline in physical activity carried out by teenagers. The overall objective of this mixed method is to investigate the effects of the Pokemon Go programme to promote physical activity in teenagers during the COVID-19 crisis. This research was conducted through a mixed method approach. 94 teenagers enrolled in 10-12 grade from three high schools agreed to be involved as subjects in this study. The subjects were allocated into 2 groups, namely in the Pokemon Go intervention programme group (N = 47) and a control group that did not get any physical activity (N = 47). The Pokemon Go intervention programme was carried out for 7 weeks with an intensity of 3 times a week in physical education classes. After carrying out the Pokemon Go intervention programme, the forty-seven subjects were interviewed. The quantitative instrument used to measure the physical activity level was IPAQ, while the qualitative instrument used in-depth interviews. Teenagers with the status of players, ex-players and non-players experienced a significant increase in physical activity level after participating in the Pokemon Go intervention programme for 7 weeks, and the majority of subjects considered that Pokemon Go had a positive effect to promote physical activity during the COVID-19 pandemic. After implementing the Pokemon Go programme for 7 weeks, the results of our study confirm that the physical activity levels of teenagers have gradually increased during the COVID-19 pandemic.

Keywords: Pokemon Go, physical activity, COVID-19, mixed method

INTRODUCTION

In this COVID-19 era, physical activity (PA) among teenagers and adults is drastically declining (Yan et al., 2020). Previous studies reported that physical activity has an important contribution in maintaining a healthy body, fitness and avoiding chronic diseases, such as heart disease, obesity, cancer, diabetes (Dietz et al., 2016), and hypertension (Lee et al., 2021). Another study reported that, globally, more than a quarter of adults were physically inactive, which caused 5 million deaths per year (Ni et al., 2019). According to the study results by Xian et al., (2017), notwithstanding that exercise has been carried out and well documented, PA levels were still low in some countries. Based on this fact, innovative strategies to increase PA need to be promoted in the current COVID-19 era.

Previous studies recommended Pokemon Go as a strategy to promote the low PA levels (Madrigal-Pana et al., 2019; Khamzina et al., 2020). Pokemon Go is an augmented reality game; a player has to find and get cartoon characters in the real world or in the surrounding environment (e.g., house, yard, park, school) (Howe et al., 2016). According to Ma et al., (2018), this game created a condition where players can catch and fight monsters (Pokemon) in the real

world. Pokemon Go has an advantage by utilising the Global Positioning System (GPS) and compatible devices with cameras so that players feel as if they are experiencing fantasy in the real world (Yan et al., 2020). Previous studies have reported that Pokemon Go had a positive effect on increasing PA levels (Ayers et al., 2016) because this game encourages people to walk or run to catch monsters (Pokemon), collect candy or hatch eggs (Wong, 2017;Wattanapisit et al., 2018). Although the benefits of Pokemon Go had been reported and documented, it was claimed that this game could cause traumatic injuries, for example, the players could fall, hit trees or walls, and even cause traffic injuries due to playing while walking, cycling or driving a vehicle. There were some data reported that the negative impact of playing Pokemon Go was seen in serious injuries to players in 10.7% of all events, and the most common side effect was musculoskeletal or skin injuries (68.0%) (Li et al., 2021). In addition, a study found that the long-term effects of Pokemon Go on increasing PA and health were not yet tested (An & Nigg, 2017). Based on the fact that some gaps were found in previous studies, it was suggested that further research on Pokemon Go needs to be conducted and should be a major concern.

Previous studies on Pokemon Go have been reported internationally (Clark & Clark, 2016; Licoppe, 2016; Keogh, 2016; Jin, 2016; Frith, 2017: Chaput & Leblanc, 2017; Hjorth & Richardson, 2017; Hsieh & Chen, 2019; Ewell et al., 2019; Hino et al., 2019; Sze et al., 2020; Thongmak, 2020; Richardson & Hjorth, 2020; Ellis et al., 2020; Laor, 2021; Guo et al., 2021). However, research on Pokemon Go as a strategy to increase PA levels through mixed methods has not been reported internationally. According to our knowledge, this is the first study that uses a mixed method to investigate the effects of Pokemon Go during the COVID-19 crisis because most of the previous research was conducted through longitudinal, cross-sectional, experimental, retrospective cohort studies, (Lee et al., 2021) and qualitative studies (Lindqvist et al., 2018). This study has the potential to explain the effectiveness of Pokemon Go in terms of quantitative and qualitative (mixed) parameters so that it can provide accurate information to lecturers, students, athletes, and the public regarding the importance of the Pokemon Go game for increasing the PA level of teenagers during the current dangerous pandemic crisis. Thus, this study aims to investigate the effect of playing Pokemon Go on increasing PA levels during the COVID-19 pandemic.

METHODS

Subjects
A mixed method was used as an approach in this study. The mixed method is a research that combines quantitative and qualitative research. Thus, this study aims to obtain data in the form of numbers and descriptions of interview results with subjects. The subjects in this study were teenagers who are currently undergoing education at the high school level in Cianjur City (Indonesia). The subjects were selected using the cluster random method, namely by sending messages via WhatsApp to all students enrolled in 10 to 12 grade from three schools regarding the purpose of this study, and only 94 students responded and were willing to be the subjects in this study. The subjects in this study were male (N = 50, 54.19%) and female (N = 44, 46.81%), 15 (N = 24, 25.54%), 16 (N = 32, 34.04), 17 (N=21, 22.34%), and 18 years old (N = 17, 18.09%). Their weight was 50 kg (N = 19, 20.21%), 55 kg (N = 25, 26.60%), 60 kg (N = 36, 38.30%), and 65 kg (N = 14, 14.89%). The height of the participants was 155 cm (N = 24, 25.53%) 160 cm (N = 39, 41.49%), 165 cm (N = 19, 20.21%), and 170 cm (N = 12, 12.77%). The subjects came from senior high school 1 Cipanas (N = 29, 30.85%), senior high school 2 Cianjur (N = 41, 43.62%) and senior high school 1 Ciranjang (N = 24, 25.53%). They attended 10 grade (N = 59, 62.77%), 11 grade (N = 21, 22.34%) and 12 grade (N = 14, 14.89%). As for the play status, there were players (N = 30), ex-players (N = 24) and non-players (N = 40).

MEASURING INSTRUMENT

QUANTITATIVE INSTRUMENTS

The International Physical Activity Questionnaire was used to measure the PA level. This instrument has been validated and has a validity value of 0.087, while the reliability was 0.77 and the questionnaire has been translated into Indonesian. IPAQ was used to measure three types of activities, namely high intensity PA, moderate PA and low PA (walking). These three PAs have different MET values, for example, high PA = 8.0 METs, medium PA = 4.0 METs and low PA (running) = 3.3 METs. The total PA scores of the three activities between high, medium and low were combined and expressed in MET-min/week (Wong, 2017).

QUALITATIVE INSTRUMENTS

In the qualitative research, researchers used in-depth interviews with subjects about their experiences during the Pokemon Go programme. Interviews were carried out by using Indonesian language with a duration of 10-15 minutes per day, online through the WhatsApp platform. The interviews were recorded and noted in books, then analysed by 3 experts who have PhD degrees in physical education and sports.

Procedure
This research was conducted from November to December 2021 at Suryakancana University. This research has obtained a permission from the Research Committee (N0:270.75/SP2H/UN64.10/

LL/2021) of the Suryakancana University (Indonesia). In addition, this research has followed the ethical guidelines of the World Medical Association (Helsinki Declaration) for human subjects. In quantitative research, 94 subjects were divided into two groups, namely the experimental group (N = 47) which received the Pokemon Go programme and the control group (N = 47) which only did daily activities at school or did not receive any physical activity programme. The pre-test and post-test activities were carried out by sending the IPAQ via WhatsApp to all subjects so that they could fill in the questionnaire individually under the supervision of the research team. The Pokemon Go programme started from 08.00-09.00 AM during education classes and was carried out for 7 weeks with an intensity of 3 meetings per week. In addition, this study applied the COVID-19 health protocol, namely checking body temperature, providing hand sanitiser and vaccines to subjects.

As for qualitative research, all subjects were interviewed online by researchers regarding their experiences after participating in the Pokemon Go programme for 7 weeks. The questions are as follows: (a) The experience of the intervention (Pokemon Go programme), (b) the advantages of the Pokemon Go programme and (c) the disadvantages of the Pokemon Go programme.

Statistical analysis

QUANTITATIVE ANALYSIS

Quantitative data were processed to analyse descriptive statistics presented as mean, standard deviation (SD) and percentage. In addition, all data were checked for normal distribution using the Kolmogorov-Smirnov test. Meanwhile, the independent t-test was used for comparison between the experimental and control groups. Then, the effect size (ES) was used to estimate the significance of the group mean differences. All quantitative data were processed using IBM SPSS software (v25.0, SPSS Inc., Chicago, IL, USA) with a significance level of 0.05.

QUALITATIVE ANALYSIS

Qualitative data were processed through thematic analysis. There were several steps in the thematic analysis that need to be taken, including: (a) Interviews were transcribed word for word (b) The transcribed interview was read repeatedly by the researcher/expert to gain a broad understanding (c) The data was sorted by categorisation, coding and highlighting based on their similarity (Rasmitadila et al., 2020) (d) Similar phrases were grouped and organised into themes (Ekström et al., 2017).

RESULTS

The normality test in this study was normally distributed (p = 0.246 > 0.05). The results of the quantitative study show that there was a significant increase in total PA in teenagers with the player status due to the impact of the Pokemon Go programme (Table 1). Similar results also occurred in teenagers with the ex-player status (Table 2) and non-player status (Table 3). Meanwhile, there was no increase in PA levels in the control group in all statuses.

Table 1 : Differences in the Pokemon Go group and control group values in walking PA, moderate PA, and vigorous PA of players

Physical Activity	Pokemon Go Group (N = 15)				Control Group (N = 15)			
	Pre-test M(SD)	Post-test M(SD)	p	ES (d)	Pre-test M(SD)	Post-test M(SD)	p	ES (d)
Walking PA (METmin/ week)	598.4 (356.0)	558.8 (342.1)	0.000*	0.64	187.4 (63.1)	173.8 (61.7)	0.342	0.002
Moderate PA (METmin/ week)	653.3 (383.5)	664.8 (362.7)	0.003*	0.71	114.6 (85.3)	101.3 (79.8)	0.521	0.001
Vigorous PA (METmin/ week)	629.3 (367.2)	1024.0 (433.1)	0.002*	0.75	224.0 (113.9)	208.0 (89.7)	0.339	0.000
Total PA (METmin/ week)	1881.1 (456.1)	2246.8 (742.4)	0.000*	0.78	525.6 (162.6)	483.1 (128.5)	0.279	0.000

*Significant difference between groups (p < 0.05).

Table 2 : Differences in the Pokemon Go and control group values in walking PA, moderate PA and vigorous PA of ex-players

Physical Activity	Pokemon Go Group (N = 12)				Control Group (N = 12)			
	Pre-test M(SD)	Post-test M(SD)	p	ES (d)	Pre-test M(SD)	Post-test M(SD)	p	ES (d)
Walking PA (METmin/ week)	533.5 (369.3)	561.5 (218.9)	0.000*	0.69	203.5 (44.1)	192.5 (52.3)	0.221	0.000
Moderate PA (METmin/ week)	733.3 (331.3)	1063.3 (288.1)	0.000*	0.77	96.6 (43.3)	90.0 (38.6)	0.178	0.001
Vigorous PA (METmin/ week)	466.6 (278.8)	893.3 (492.9)	0.007*	0.72	186.6 (104.2)	193.3 (99.2)	0.264	0.001
Total PA (METmin/ week)	1733.5 (423.2)	2517.6 (650.7)	0.001*	0.80	486.8 (100.0)	475.8 (101.5)	0.380	0.002

*Significant difference between groups (p < 0.05).

Table 3 : Differences in the Pokemon Go and control group values in walking PA, moderate PA and vigorous PA of non-players

Physical activity	Pokemon Go Group (N = 20)				Control Group (N = 20)			
	Pre-test M(SD)	Post-test M(SD)	p	ES (d)	Pre-test M(SD)	Post-test M(SD)	p	ES (d)
Walking PA (METmin/ week)	506.5 (252.0)	598.95 (305.3)	0.004*	0.64	196 (43.4)	202.9 (22.1)	0.321	0.000
Moderate PA (METmin/ week)	642.0 (398.8)	896.0 (366.7)	0.001*	0.71	98.0 (39.9)	94.0 (43.5)	0.201	0.001
Vigorous PA (METmin/ week)	592.0 (371.0)	1012.0 (468.8)	0.000*	0.78	200.0 (105.4)	124.0 (60.7)	0.111	0.001
Total PA (METmin/ week)	1740.5 (687.3)	2506.9 (666.5)	0.000*	0.79	494.3 (98.8)	420.9 (64.4)	0.108	0.002

*Significant difference between groups (p < 0.05).

THEME 1: EXPERIENCE OF INTERVENTION

The results of qualitative research through interviews with subjects are presented in three themes:

This first theme discusses the subjects' experience when participating in the Pokemon Go programme for 7 weeks. Intervention experience is an important factor that needs to be known in order to provide an overview of the effectiveness of the Pokemon Go programme. The subjects gave their opinion as follows:

"I'm excited to be able to join the Pokemon Go programme because this game is very interesting and motivates me to walk."

"At the beginning of the intervention, I felt that this game was boring, but after getting a lot of Pokemon monsters, I liked the game."

"I've played this game previously, but I thought Pokemon Go can hurt me. But my opinion was changed because the location of the intervention in this study was carried out in an area of the university that was far from the city centre, and there were no vehicles." "Before taking part in this research, I have

often played this Pokemon Go game and I confirm that this game is safe if it is done in a place far from vehicles, such as parks or hills. And I like this game because it triggers me to want to walk or run to find Pokemon monsters."

THEME 2: POKEMON GO PROGRAMME ADVANTAGES

The second theme is about the advantages of the Pokemon Go game, which is indeed an important factor and must be presented to everyone. The subjects argued that:

"I presume that the advantage of playing Pokemon Go is that it can gradually increase our PA level. For example, before participating in the Pokemon Go intervention, I rarely did PA outside the house, especially during hot weather or the current pandemic situation. But, Pokemon Go has helped me to have a much better PA level."

"In my opinion, Pokemon Go is one of the games that promotes PA in a positive way to teenagers in the current COVID-19 pandemic crisis. The advantage of this game is that it can be played at any time, we just need to provide a smartphone with mobile data."

"This game is incredibly fun because it allows me to walk for an hour without feeling bored or tired. I will continue to play this game, even after the research has been completed."

"I believe that Pokemon Go can be one of the right strategies to increase PA levels during the current COVID-19 pandemic because this game can be played individually and doesn't require many friends."

"I can't believe it!! This Pokemon Go game triggers me to walk 1.2 km every day. This game is a great method for teenagers to increase their PA level even during a pandemic."

THEME 3: THE DISADVANTAGES OF THE POKEMON GO PROGRAMME

This third theme discusses the shortcomings of the Pokemon Go game that must be investigated accurately in order to minimise the weakness. The subjects revealed their opinion, stating that:

"Pokemon Go is indeed a game that can promote improvement in PA levels, but if the game is not played in a safe place, it can result in injury (e.g., falling, crashing into a tree or wall, being hit by a vehicle)."

"In my opinion, Pokemon Go has several weakness, such as: it requires a fairly large mobile data plan and we should have a smart phone with good quality in order to play this game."

"If the internet network is bad, then Pokemon Go cannot be used to increase our PA level. In addition, if it is raining, then we cannot walking outside the house. And the GPS signal sometimes gets interrupted, so players can't walk to search Pokemon monsters."

DISCUSSION

Overall, the objective of this study was to evaluate the effects of the Pokemon Go game from a mixed method point of view on increasing PA levels during the COVID-19 period. The quantitative and qualitative (mixed) research confirm that the Pokemon Go programme has been shown to positively promote PA levels in teenagers to higher levels in the current COVID-19 crisis. The results of this study are in line with previous studies which explained that Pokemon Go is an augmented game that requires players to travel to various locations in the real world, and the distances are relatively far. Thus, after carrying out this game, players can increase their PA level to be better than before (Howe et al., 2016; Althoff et al., 2016; Chaput & Leblanc, 2017; Ewell et al., 2019; Kosa & Uysal, 2022).

Teenagers with the status of players, ex-players and non-players who have participated in the Pokemon Go intervention programme reported that they were able to walk 60 minutes in a day (Ni et al., 2019) and experienced an increase in walking distance with an average of 1.5 km. Similarly, a study conducted in the US reported that the effects of Pokemon Go can lead to an average increase of 1473 runs in a day, while the research of Howe et al., (2016) noted that players experienced an increase of 955 steps per day (Wattanapisit et al., 2018).

In addition, this study refutes previous research reporting that Pokemon Go was not effective if used in the long term to increase PA levels (An & Nigg, 2017; (i et al., 2021). The fact is the Pokemon Go intervention programme, which was implemented for 7 weeks, was effective for increasing PA levels in teenagers despite the current pandemic crisis. The main issue that is often found in previous studies is the safety or of players (Wong, 2017; Marquet et al., 2017; Wattanapisit et al., 2018), but our research confirms that none of the teenagers got injured while playing Pokemon Go. This is because we had prepared a wide and safe environment for them to play.

CONCLUSIONS

This study becomes evidence that the Pokemon Go programme is one of the strategies that has a positive effect in promoting PA among teenagers at a high school level during the COVID-19 crisis. The scope of this study was limited in terms of the subjects who came from one area in Indonesia. Thus, future studies need to be carried out by targeting subjects from different ages, including children, adolescents and adults in several regions in Indonesia or other countries.

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POKEMON GO U DOBA COVID-19: DA LI UTIČE NA PROMOCIJU FIZIČKE AKTIVNOSTI TINEJDŽERA?

Jedan od glavnih problema tokom pandemije COVID-19 koji se mora uzeti u obzir jeste smanjenje fizičke aktivnosti kod tinejdžera. Cjelokupni cilj ove mješovite metode je istražiti uticaj Pokemon Go programa na promociju fizičke aktivnosti kod tinejdžera tokom krize COVID-19. Ovo istraživanje je provedeno koristeći pristup mješovite metode. 94 tinejdžera koji pohađaju 10-12 razred iz tri srednje škole je dalo pristanak za učešće u formi ispitanika u ovoj studiji. Ispitanici su podijeljeni u 2 grupe, i to u grupu Pokemon Go programa intervencije (N = 47) i kontrolnu grupu koja nije učestvovala u fizičkim aktivnostima (N = 47). Pokemon Go program intervencije je proveden u trajanju od 7 sedmica uz intenzitet od 3 puta sedmično tokom časova fizičkog obrazovanja. Nakon provođenja Pokemon Go programa intervencije, četrdeset i sedam ispitanika je učestvovalo u intervjuu. Kvantitativni instrument koji se koristio za mjerenje nivoa fizičke aktivnosti je bio IPAQ, dok je kvalitativni instrument bio u formi sveobuhvatnih intervjua. Tinejdžeri sa statusom igrača, bivših igrača i onih koji nisu igrači su imali značajno povećanje nivoa fizičke aktivnosti nakon učešća u Pokemon Go programu intervencije tokom 7 sedmica, a većina ispitanika je smatrala da je Pokemon Go imao pozitivan uticaj na promociju fizičke aktivnosti tokom pandemije COVID-19. Nakon primjene Pokemon Go programa tokom 7 sedmica, rezultati naše studije potvrđuju postupno povećanje nivoa fizičke aktivnosti tinejdžera tokom pandemije COVID-19.

Ključne riječi: Pokemon Go, fizička aktivnost, COVID-19, mješovita metoda

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THE EFFECT OF THE VOLLEYBALL TRAINING PERIOD ON THE SPINAL COLUMN STATUS IN THE SAGITTAL PLANE

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ABSTRACT

Introduction: Volleyball is one of the most popular sports practiced in both the professional and amateur form. The specificities of the volleyball game, such as jumping, landing, spiking, and other elements, can cause changes, i.e., asymmetry in the very body posture resulting from the use of one side of the body. This contributes to the development or deterioration of postural deformities. Problem and aim: The aim of the research was to analyse the female volleyball players' postural status in the sagittal plane in relation to the length of the training period and examine the effect of muscle force in the cervical spine using a computer postural analysis. Methods: The research was designed in the form of a cross-sectional study and conducted in the private practice of a physiatrist, "Sporticus" - Dr Buljugić. The postural status of female subjects, who train in the volleyball clubs "Centar Ort" and "Block out" from Sarajevo, was assessed using a computer postural analysis in the sagittal plane. Results: The research comprised 40 subjects, where the oldest subject was 25 and the youngest 11 years old. The analysis of the postural status in the sagittal plane established that there are no statistically significant deviations in relation to the volleyball training period. The average value of the neck pressure expressed as the load in kilogram-force of the subjects from the examined group was 13.98 ± 6.19 kg. Conclusion: It is necessary to draw the attention of trainers to the need of including preventive and corrective exercises in daily training, i.e., exercises intended for improving the development of good body posture and aiding in maintaining it.

Keywords: volleyball, postural status, cervical spine load, Q-angle, sagittal plane

INTRODUCTION

Athletes' body posture is an area of interest for numerous researchers who seek to determine the potential relationship between postural imbalance and asymmetrical load accumulation as well as the appearance of specific injuries (1, 2, 3). Volleyball is considered an ideal model of a health-related physical activity as it improves all body functions, starting from the cardiorespiratory system to the decrease in the appearance of cerebrovascular and cardiovascular diseases, all the way to the very spinal column diseases (4). As a sport, volleyball abounds with fast and forceful movements of the entire body, and it requires not only an exquisite level of physical fitness, but also good posture of the body as a whole and of its individual segments (5). Volleyball has a positive effect on the body due to symmetric movements, i.e., the use of both hands. However, volleyball can have a negative effect on posture. Due to certain characteristics of volleyball as a sport, parts of its technique are asymmetrical because they are played with one hand, exposing the female volleyball players to factors which can

bring about the development of postural deformities. Technical elements, such as the jump serve and spike, contribute to the occurrence of asymmetry between the left and right side of the body, while elements like a dive and a block as well as setting do not cause asymmetry between the left and right side of the body. Considering the specificities of the volleyball game, there is often an occurrence of single-leg landings (6). The concept of stability and mobility is extremely clear and adaptable in sports exhibiting asymmetry. Individual corrective programmes are extremely important, since the playing positions generate different loads and deformations of the locomotor system. It was determined that asymmetry occurs with respect to the dominant position being played (7). Current research proved the shortening of paravertebral muscles, namely trapezius muscle and pectoralis major muscle, as well as insufficient strength of the lower part of abdominal muscles. In professional volleyball engagement, it is just a matter of time when the asymmetry and development of muscle imbalance will occur, and thus the role of a trainer is to prevent and nullify all types of asymmetry through the training method and individualised programme (8). Special attention is paid to the effect of sports practice on the formation of anteroposterior curvature of the spine. That is why it is important to take special care of a young athlete, and to bear in mind that training programmes should not only aim at the result, but should also foster the harmonious development of a young organism (9).

PROBLEM AND AIM

The aim of the research was to analyse the female volleyball players' postural status in the sagittal plane in relation to the length of the training period and examine the effect of muscle force in the cervical spine using a computer postural analysis.

METHOD

The research was designed as a cross-sectional prospective study. The research comprised 40 female subjects who train in the volleyball clubs "Centar Ort" and "Block out" from Sarajevo. The study was conducted in the private practice of a physiatrist, "Sporticus" - Dr Buljugić from 17/02/2020 to 30/07/2020. The postural status of female subjects was assessed using a computer postural analysis in the sagittal plane.

STATISTICAL DATA

The results are tabulated and graphically presented through the number of cases, percentages, arithmetic means with standard deviation and standard error, and the range of values. The comparison in relation to the length of the training period was conducted using the one-way analysis of variance (ANOVA), while the effect of the training period on the observed parameters was investigated using the Spearman's rank correlation coefficient. The results of the tests were considered statistically significant at the level of confidence of 95% or $p < 0.05$. The analysis was conducted using the Statistical Package for the Social Sciences, IBM Statistics SPSS v 25.0.

RESULTS

The research comprised 40 female volleyball players out of whom 20 train in the volleyball club "Block out" Sarajevo and 20 in the volleyball club "Centar Ort" Sarajevo. The average age of the female subjects was 17.18 ± 3.07 years. The oldest subject was 25 and the youngest 11 years old.

Table 1 : Comparison of the average deviation in the lateral position of the head in relation to the training period

		N	X̄	SD	SE X̄	Min.	Max.
Lateral position of the head	Up to 5 yrs	9	13.67	4.44	1.48	7.0	19.0
F = 0.297	5 - 7 yrs	10	15.30	7.54	2.39	2.0	27.0
p = 0.828	7 yrs	11	13.18	7.37	2.22	3.0	27.0
ro = -0.084	Over 7 yrs	10	12.90	4.68	1.48	7.0	22.0
p = 0.608	Total	40	13.75	6.09	0.96	2.0	27.0

Comparison of the average deviation values pertaining to the lateral position of the head in relation to the training period indicates that, when it comes to the training period of up to 5 years, it was 13.67 ± 4.44o; for the period of 5 - 7 years, it was 15.3 ± 7.54o; for the training period of 7 years, it was 13.18 ± 7.37o; and over 7 years, it was 12.9 ± 4.68o. Statistical analysis shows that there is no significant difference or correlation in the average value, compared to the training period ($p > 0.05$).

Table 2 : Comparison of the average deviation in the lateral position of the pelvis (inclination position) in relation to the training period

		N	X̄	SD	SE X̄	Min.	Max.
Lateral position of the pelvis (inclination position)	Up to 5 yrs	9	7.22	2.86	0.95	4.0	13.0
F = 1.907	5 - 7 yrs	10	8.90	5.09	1.61	3.0	22.0
p = 0.146	7 yrs	11	5.36	3.91	1.18	-2.0	12.0
ro = 0.038	Over 7 yrs	10	8.20	1.48	0.47	5.0	11.0
p = 0.818							

Comparison of the average deviation values pertaining to the lateral position of the pelvis in relation to the training period indicates that, when it comes to the training period of up to 5 years, it was 7.22 ± 2.86o; for the period of 5 - 7 years, it was 8.9 ± 5.09o; for the training period of 7 years, it was 5.36 ± 3.91o; and over 7 years, it was 8.2 ± 1.48o.
Statistical analysis shows that there is no significant difference or correlation in the average value, compared to the training period (p > 0.05).

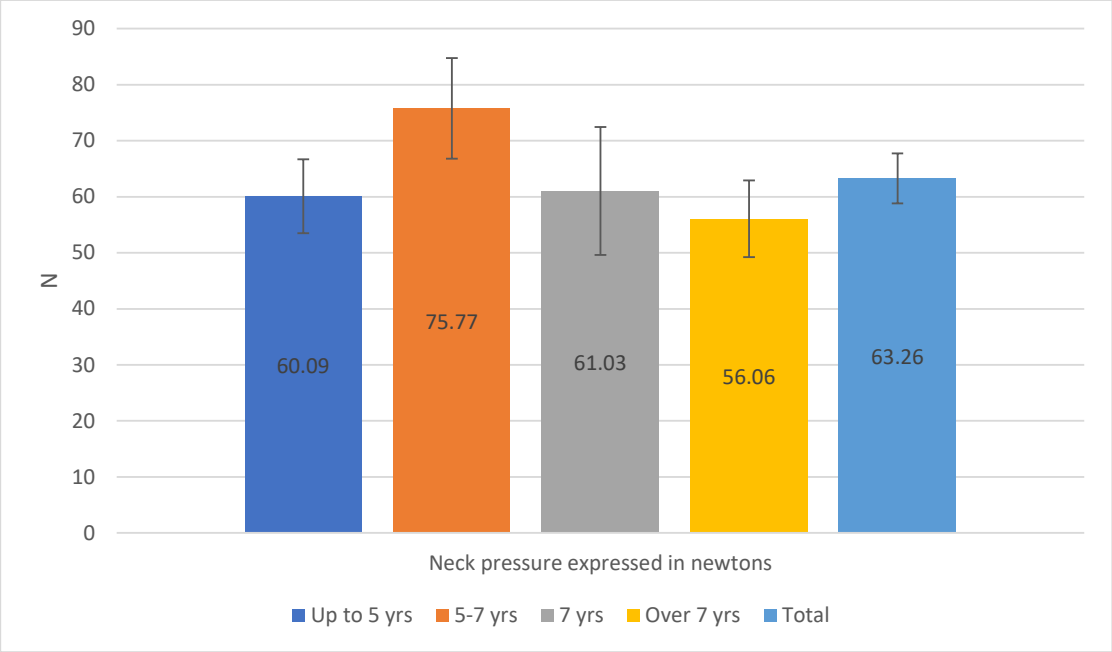

Chart 1. Comparison of the neck pressure expressed in newtons with reference to the training period

Comparison of the average values of neck pressure in relation to the training period indicates that, when it comes to the training period of up to 5 years, it was 60.09 ± 19.84 N; for the period of 5 - 7 years, it was 75.77 ± 28.34 N; for the training period of 7 years, it was 61.03 ± 37.87 N; and over 7 years, it was 56.06 ± 21.61 N.
Statistical analysis shows that there is no significant difference or correlation in the average value, compared to the training period (p > 0.05).

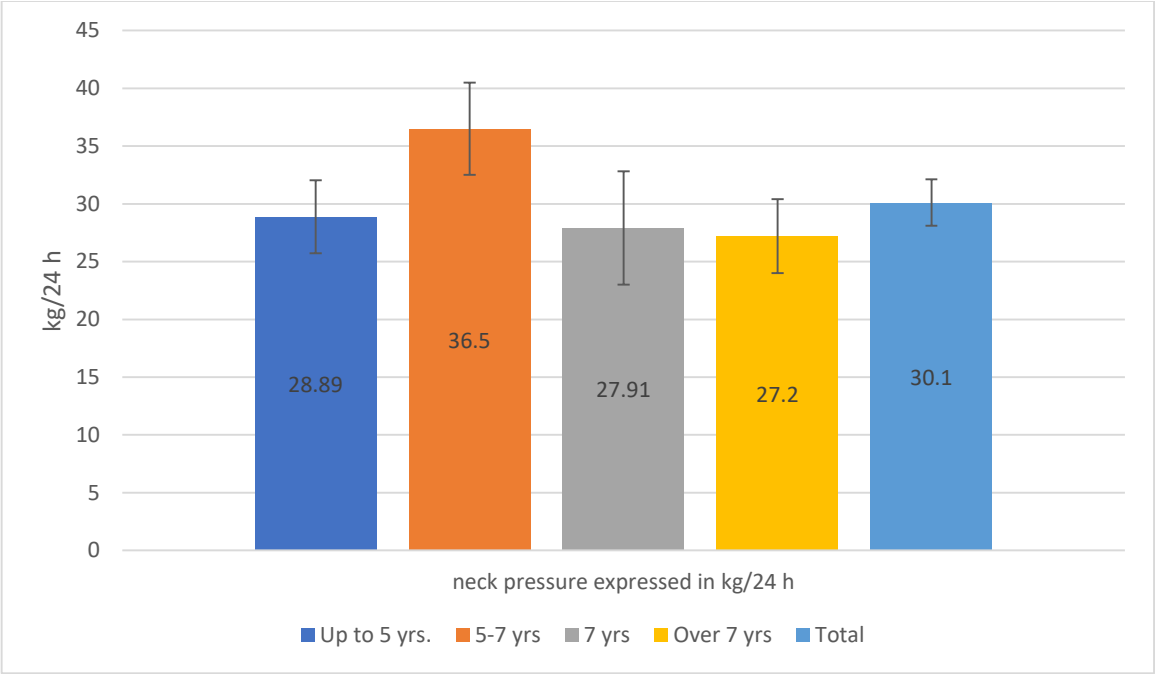

Chart 2. Comparison of the neck pressure expressed in kilograms during 24 hours with reference to the training period

Comparison of the average values of neck pressure expressed in kilograms during 24 hours in relation to the training period indicates that, when it comes to the training period of up to 5 years, it was 28.89 ± 9.48 kg/24 h; for the period of 5 - 7 years, it was 36.5 ± 12.62 kg/24 h; for the training period of 7 years, it was 27.91 ± 16.29 kg/24 h; and over 7 years, it was 27.2 ± 10.15 kg/24 h.

Statistical analysis shows that there is no significant difference or correlation in the average value, compared to the training period ($p > 0.05$).

Table 3 : Comparison of the average deviation in the lateral position of the pelvis (inclination position) in relation to the training period

		Training period (years)
Neck pressure expressed in N	ro	-0.025
	p	0.877
	N	40
Neck pressure expressed in kg/24 h	ro	-0.028
	p	0.863
	N	40
Q-angle or upper leg angle - right leg	ro	-0.154
	p	0.344
	N	40
Q-angle or upper leg angle - left leg	ro	-0.071
	p	0.662
	N	40
Height loss measured against the actual body height (%)	ro	-0.095
	p	0.560
	N	40
Posture number	ro	-0.005
	p	0.973
	N	40
2nd disc of the 2/3 cervical vertebrae (ft/lbs)	ro	-0.026
	p	0.874
	N	40
5th disc of the L5/S1 vertebrae (ft/lbs)	ro	-0.026
	p	0.874
	N	40
Percentage of change in muscle thickness (kgs)	ro	-0.027
	p	0.867
	N	40
Percentage of change in muscle thickness (%)	ro	-0.024
	p	0.881
	N	40

The correlation between the length of the volleyball training period and the computer postural analysis elements does not indicate a statistically significant correlation (all $p > 0.05$).
The coefficients are extremely low, and only in the case of correlation with the Q-angle (the upper leg angle) of the right leg, we can say that there is a mild negative correlation ($ro = -0.154$; $p > 0.05$).

DISCUSSION

Sports and all forms of exercise have a confirmed health and prevention effect (10); however, even though sports activities positively affect the reduction of deformities, the majority of researchers came to the conclusion that a large number of repeated movements in sports and muscle imbalance affect the incidence and development of certain disorders in body posture (11). Due to certain characteristics of volleyball as a sports discipline (parts of its technique that are asymmetrical because they are played with one hand), there is reasonable doubt that volleyball players are exposed to factors which can bring about the development of postural deformities (12). The serve and attack comprise a series of asymmetrical movements which negatively affect body posture, especially in developing adolescents (13). In their study, Tillman and Hass have shown that, in volleyball, the upper extremities are not the only ones exhibiting asymmetry, but lower extremities can also exhibit it, since 45% of offensive and 43% of defensive landings are unilateral (14).

Based upon the results obtained in this research, it was not found that regular volleyball training leads to postural deviations. Grabara has compared body posture on a sample of 104 young volleyball players aged 14 to 16, investigating whether age and anthropometric characteristics affect body posture. She discovered that volleyball training did not have a negative effect on body posture. Additionally, she discovered that the training period did not negatively affect body posture (15). The research conducted by Andrašić et al., who evaluated the body posture of female volleyball players in different age categories on a sample of 60 female volleyball players aged 8 to 16, pointed to the existence of certain types of irregular body postures in all age groups, connecting this phenomenon with regular volleyball practice. They consider that volleyball can also have a corrective effect on the postural status, but the most intensive elements of this sport (spike, serve and a combination of the two elements) can affect the appearance of an irregular postural development, especially during adolescence. The authors believe that a certain percentage of female volleyball players have a tendency to additionally develop structural changes when they continue playing volleyball (16). Grabara's results are in correlation with the results obtained in our research, while the results obtained by Andrašić et al. are not in correlation with the results of our research.

Our research results have indicated that, considering the training period, the lateral positions of the head and pelvis do not show significant deviations. The research conducted by Grabara comprised 32 volleyball players, and body posture was assessed using the photogrammetric method. The participants were examined 3 times at the ages of 14, 15 and 16. The studied volleyball players' training experience at the time of the first measurement was less than 5 months. In the volleyball players, asymmetry was noted in the pelvis position, in addition to the shoulder asymmetry. The authors consider that volleyball training did not affect the asymmetry (17). Grabara's research results have similarities with the results obtained in our research stating that volleyball training does not affect postural deviations.

According to the results of our research, the value of neck pressure expressed in kilograms and/or newtons did not show significant differences or correlation in relation to the length of the training period. In their study, Duan et al. proved that activities which require forward bending of the upper body caused tenfold more compressive stress on the vertebrae, compared with standing upright (18). In their research, Yin et al. state that the line of gravity in longissimus and iliocostalis muscles can be altered by spinal flexion, where it consequently decreases their resistance to shear force but increases their resistance to compression force. The maximal compressive force which the vertebral body can bear is related to bone density and is between 2 and 12 kN (19).

The analysis of our research results concerning the correlation between the length of the volleyball training period and the computer postural analysis elements does not indicate a statistically significant correlation, except in the case of correlation with the Q-angle of the right leg which showed a mild negative correlation. The research conducted by Fatahi et al. on 70 elite male and female volleyball players aged 26.43 ± 3.56, who are members of the Iran national team, proved that the average standard deviation of the Q-angle was 12.34 ± 2.36° for the right and 12.48 ± 2.62° for the left leg. The authors concluded that there were no significant differences between the right and left Q-angle in male and female volleyball players (20). The research results obtained by Fatahi et al. have similarities with our own results, since it can be concluded that there are no great deviations of the Q-angle pertaining to the left and right leg.

A study conducted in Albania by Genti and Kaçurri aimed at assessing the body posture of Albanian male and female volleyball players aged 18 to 32. Zebris System Win Spine 2.3 software was used to

examine the body posture. Posture analysis in the upright sagittal projection, upright frontal projection and upright transversal projection showed postural asymmetry. The authors concluded that good posture plays a key role, and that it is necessary to conduct further research focusing on the prevention of postural problems which are specific for volleyball (21).

CONCLUSION

The research results have confirmed that the length of the volleyball training period does not affect the frequency of postural deviations related to the spinal column in the sagittal plane of female volleyball players, and the average value of neck pressure in the subjects of the examined group was 13.98 ± 6.19. It is necessary to draw the attention of trainers to the need of including compensation exercises in daily training, i.e., exercises intended for improving the development of good body posture and aiding in maintaining it.

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UTICAJ DUŽINE TRENIRANJA ODBOJKE NA STATUS KIČMENOG STUBA U SAGITALNOJ RAVNI

Uvod: Odbojka je jedan od najpopularnijih sportova kako u profesionalnom tako i u amaterskom obliku. Specifičnosti odbojkaške igre, kao što su skok, doskok, smeč i drugi elementi, korištenjem jedne strane tijela mogu izazvati promjene odnosno asimetrije u samom držanju tijela. To pogoduje razvoju ili povećanju posturalnih deformiteta. Problem i cilj: Cilj istraživanja je bio analizirati posturalni status odbojkašica u sagitalnoj ravni u odnosu na dužinu trajanja treniranja, te ispitati djelovanje mišićne sile u vratnom segmentu kičmenog stuba kompjuterskom posturalnom analizom. Metode: Istraživanje je dizajnirano kao presječna studija, a provedeno je u privatnoj ordinaciji specijaliste fizijatra „Sporticus" - dr. Buljugić. Posturalni status ispitanika ženskog spola koje treniraju u odbojkaškom klubu „Centar Ort" i odbojkaškom klubu „Block out" iz Sarajeva se procjenjivao kompjuterskom posturalnom analizom u sagitalnoj ravni. Rezultati: Istraživanje je obuhvatilo 40 ispitanica, pri čemu je najstarija ispitanica imala 25 godina, a najmlađa 11 godina. Analizom posturalnog statusa u sagitalnoj ravni ustanovljeno je da ne postoje statistički značajna odstupanja u odnosu na dužinu treniranja odbojke. Prosječna vrijednost vratnog pritiska izraženog u kilogramima opterećenja kod ispitanica ispitivane grupe je iznosila 13,98 ± 6,19 kg. Zaključak: Potrebno je skrenuti pozornost trenerima na potrebu uključivanja preventivno-korektivnih vježbi u svakodnevni trening, odnosno vježbi koje poboljšavaju razvoj i pomažu u održavanju dobrog držanja tijela.

Ključne riječi: odbojka, posturalni status, opterećenje na vratnu kralježnicu, Q ugao, sagitalna ravan

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POSTURAL STATUS AND INJURIES AMONG KARATE ATHLETES OF YOUNGER SCHOOL AGE FROM VOJVODINA

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ABSTRACT

The research was conducted on a sample of 150 female karate athletes and 150 male karate athletes aged 6-12 during the Vojvodina Championship in Kikinda organised by KC Haiken, with over 450 competitors from karate clubs of Vojvodina. The research subject was related to the postural status and injuries in karate athletes of younger school age. The aim of the research was to determine the postural status of the respondents as well as injuries that occurred during the training or competition process in karate so as to possibly apply new training methods. In addition to the data collected by measuring the status of the spine, ankles and feet, for the purposes of the research, a special questionnaire was also formulated, referring to the injuries received by the respondents. Descriptive statistics measures were used in this transversal study. The results of the research indicate that lordotic posture is represented by 36% in girls and 46.7% in boys, while kyphotic posture is present in an incomparably smaller rate, with 10% in girls and 8.7% in boys. The foot arch was 40% more pronounced in girls, while it was 38.7% in boys. Out of the total number of respondents, 17 (5.7%) never had an injury, while the remaining 283 (94.3%) experienced some injuries when engaging in sports. The obtained research results indicate the necessity of applying new training methods and the need to apply corrective gymnastics exercises.

Keywords: posture, spine, foot, injuries, children, karate

INTRODUCTION

Nowadays, karate is one of the most popular individual martial arts, and it is defined by two competitive disciplines: sports fighting (kumite) and forms (kata). Because of these two disciplines, karate is becoming one of the most attractive sports today. In order to achieve top performance and the best result in both disciplines, a high level of motor and functional abilities, as well as anthropometric and mental characteristics are necessary. However, it is important to emphasise that movement training is extremely important, especially in karate. The movement technique has existed since the very beginning of karate and it is its inseparable part because it refers to footwork, movement control and master movement (Bubalo, 2005). Learning the movement technique, such as new ways of moving the body from one position to another, is a very difficult phase of training for beginners. In Shotokan, for example, movement is performed with bent legs and low body CG so that more use is made of the leg muscles, which is a completely different movement from the way we usually move, and even from the movement in other sports.

Proper/good posture contributes to the importance of performing specific movement activities in karate, which is especially important for beginners during training. The postural status related to body posture is of great importance for all people, especially for athletes/karatekas. Determining the postural status of female and male karate athletes of younger school age can contribute to their further proper development and timely correction in case of a postural disorder.

Injuries are, unfortunately, an integral part of every training and competition in martial arts, which are presented to the people as violent and with

an excessive risk of injury. Such an accepted and widespread opinion in the general public cannot be considered valid because, among many facts, the most striking one is that in martial arts, there is a division into contact (boxing, judo...) and non-contact (aikido, etc.) ones; therefore, they differ in the degree of injury risk (Kalina, 2000; Ambrozy et al., 2015). It is inevitable that numerous contacts at training sessions and competitions lead to karate injuries. These injuries are mostly of a traumatic nature (sprains, strains, ruptures) (Arriaza & Leyes, 2005; Rolf, 2007; Rahimi et al., 2012). The second level of injuries occurs due to inadequate or poor muscle warm-up, poor physical fitness or overtraining. According to Peeri et al. (2011), the occurrence of injury is most often attributed to overtraining (22.4%), while the second most common cause is inadequate warm-up (19.4%). In addition, injuries to the ankle and foot are common in athletes and the general population (Pollard et al., 2002; Cvejanov-Kezunović et al., 2011; Aslan et al., 2014).

Both men and women in all categories participate in karate competitions. However, in order for karatekas to approach the competition in full psycho-physical fitness, given the specificity of karate as a contact sport, it is very important that the training process is adequately conducted. Young athletes are at a higher risk of injuries due to overexertion than older ones (Višnjevac et al., 2020). This confirms the importance of a proper approach to training planning in order to reduce the possibility of injuries to a minimum both for the health of the athletes themselves and for their safer participation in competitions. It has also been found that strict trial, application of new rules and severe penalties for uncontrolled strokes, especially for junior competitions, can significantly reduce the risk of injury (Macan et al., 2006).

PROBLEM AND OBJECTIVE

The subject of this research was related to the postural status and injuries in karate athletes of younger school age. The aim of the research was to determine the postural status of the respondents as well as injuries that occurred during the training or competition process in karate so as to possibly apply new training methods.

METHOD

In this transversal research, descriptive statistics measures were used to process the collected data by measuring the status of the spine, ankle and foot, as well as data obtained on the basis of a specially formulated questionnaire related to the injuries sustained. The measurement and survey were conducted during the Vojvodina Championship in Kikinda organised by KC Haiken, with over 450 competitors from karate clubs of Vojvodina.

T**he sample of respondents** consisted of female karate athletes (N = 150) and male karate athletes (N = 150), with a total of 300 (N = 300). All respondents were in the training process for at least 2 years and aged between 6 and 12 years. The respondents train 3 or 4 times a week for at least an hour. The research was conducted with respondents whose parents agreed to the test, and who gave their voluntary consent to the test.

The sample of variables was systematised into three groups, namely:
1. Variables for assessing the postural status of the spine
• Good postural status of the spine (BOS),
• Poor kyphotic posture (PKIFP),
• Poor lordotic posture (PLORP), and
• Poor scoliotic posture (PSCOP).
2. Variables for assessing the postural status of the foot
• Normal foot arch (BOF),
• Hollow foot (PCAVUS),
• Lowered foot arch level I (PPLAN1), and
• Lowered foot arch level II (PPLAN2).
3. Variables related to injuries
• Head injuries,
• Shoulder girdle injuries,
• Rib injuries,
• Hand injuries with fists,
• Back injuries,
• Leg injuries,
• Knee injuries, and
• Ankle injuries with the foot and toes [1].

Description of the measurement procedure and instruments

A SpineScan portable device (OrthoScan, Ltd.) was used to assess the postural status of the spine. This device allows users to quickly and accurately assess the postural status of the spine. In addition, SpineScan monitors deviations from the normal postural status of the spine. It is a non-invasive method of assessment, which means that it does not endanger the health of the respondent. Diagnosis with the device was performed on the principle of electronic spirit levels based on sensors that register movement as well as pelvic inclination. Based on the identified postural status, and using the SpineScan application software, the results are read and recorded, quantified and analysed on a laptop. "This type of measurement can be applied to any person who is able to bend or stand during the examination. There are no contraindications for use, except for persons who are not able to take a standing position, i.e., to make a forward bow from a standing position"

[1] Previous research has shown that the main cause of ankle injuries in karate is a consequence of permitted ankle techniques at the level of the ankle (kuzushi-waza).

(Romanov et al., 2014).
The postural status of the feet was determined using the method of computerised, digital podography, the Pedikom system (Pedikom Ltd, New Zealand). It is a podograph with specially lit glass on which the respondent stands. In the lower part of the device itself, there is a camera that recorded the footprint, which records and analyses the foot. All the obtained data were transferred to a laptop with the help of a software, after which they were processed, all based on the feet pressure on the glass.
For the purposes of the research, a specially formulated questionnaire was used, referring to the injuries received by the respondents, and it was also implemented after the obtained consent of the respondents' parents.

All measurements were carried out on the basic principles of the Declaration of Helsinki, which is based on ethical standards that ensure respect for every human being and protection of his health. After the measurement, the obtained data were processed in the statistical program SPSS 17.

RESULTS

Table 1 - Basic descriptive indicators of age and the number of training sessions during the week

Variable	Female karate athletes		Male karate athletes		p
	Range	AS ± SD	Range	AS ± SD	
Age	6-12	21.3 ± 3.2	6-10	19.9 ± 3.2	0.211
No. of training sessions/week	3-4	5.1 ± 2	3-4	5.4 ± 2.4	0.452

Range - minimum and maximum value; AS - arithmetic mean; SD - standard deviation; p - level of significance (at the level of $p \leq 0.05$)

Table 2 – Representation of the postural status with spinal deformities

Variables	Female karate athletes		Male karate athletes		Σ		Sig.
	No.	%	No.	%	No.	%	
BOS	50	33.3	34	22.7	84	28	
PKIFP	15	10	13	8.6	28	9.3	
PLORP	54	36	70	46.7	124	41.35	0.152
PSCOP	31	20.7	33	22	64	21.35	
N	**150**	**100%**	**150**	**100%**	**300**	**100%**	**0.007**

BOS – good postural status; PKIFP – poor kyphotic posture; PLORP – poor lordotic posture; PSCOP – poor scoliotic posture

Table 3 – Overview of the postural status of the left foot

Variables	Female karate athletes		Male karate athletes		Σ		Sig.
	No.	%	No.	%	No.	%	
BOF	51	34	55	36.7	106	35.35	
PCAVUS	8	5.3	15	10	23	7.65	
PPLAN1	31	20.7	22	14.7	53	17.7	
PPLAN2	60	40	58	38.6	118	39.3	
N	**150**	**100%**	**150**	**100%**	**300**	**100%**	

BOF – normal foot arch; PCAVUS – hollow foot; PPLAN1 – lowered foot arch level I; PPLAN2 – lowered foot arch level II

Table 4 – Overview of the postural status of the right foot

Variables	Female karate athletes		Male karate athletes		Σ		Sig.
	No.	%	No.	%	No.	%	
BOF	49	32.7	52	34.7	101	33.7	
PCAVUS	9	6	13	8.6	22	7.3	
PPLAN1	30	20	28	18.7	58	19.35	
PPLAN2	62	41.3	57	38	119	39.65	
N	**150**	**100%**	**150**	**100%**	**300**	**100%**	

BOF – normal foot arch; PCAVUS – hollow foot; PPLAN1 – lowered foot arch level I; PPLAN2 – lowered foot arch level II

Table 5 – Display of injuries on the entire sample of respondents

Variables	Female karate athletes		Male karate athletes		Σ	
	No.	%	No.	%	No.	%
No injury	12	8	5	3.3	17	5.7
Head injury	12	8	15	10	27	9
Shoulder injury	21	14	18	12	39	13
Rib injury	15	10	18	12	33	11
Hand injuries with fists	14	9.3	18	12	32	10.7
Back injury	5	3.3	3	2	8	2.7
Leg injury	7	4.7	6	4	13	4.3
Knee injury	2	1.3	8	5.3	10	3.3
Ankle injuries with the foot and toes	62	41.3	59	39.3	121	40.3
N	**150**	**100%**	**150**	**100%**	**300**	**100%**

DISCUSSION

The descriptive indicators of the analysed groups of female and male karate athletes are very uniform. Female karate athletes are, on average, slightly older than male karate athletes, and therefore (on average) have more training sessions during the week (Table 1). This homogeneity of distribution is high and characteristic for the selected groups of athletes.

Tables 2, 3 and 4 show the numerical and percentage values of spinal disorders observed from the frontal and sagittal planes as well as the postural status of the foot arch. Looking at the results as a whole, it can be concluded that, on the sample of 300 girls and boys who train at karate clubs from the territory of Vojvodina, the highest percentage of lordotic poor posture is seen in girls with 36% and boys with 46.7% (Table 2). These results coincide with the research conducted by Romanov et al. (2014). This difference has no statistical significance (0.152) when observing the results between girls and boys. It is most likely a case of weakness of the abdominal wall muscles because the respondents were school children between the ages of 6 and 12, who spend at least 8 hours a day sitting at school and at home in front of the computer. Certainly, in the sitting position, the abdominal wall muscles weaken, the upper attachment shortens and, at the same time, the lower attachment of the quadriceps femoris muscle stretches. This is a general problem for all people who have chosen sedentary jobs and inactivity as a lifestyle. Contrary to this claim, kyphotic poor posture was detected in the respondents. This percentage is incomparably lower, compared to lordotic poor posture (10% of girls and 8.7% of boys). These are approximately the same results, so it can be concluded that we are working with the examinees to strengthen the thoracic part of the spine, which is logical if the motor movements of the upper part of the body in karate are observed. Observing girls and boys, there are small differences in spinal deformities, but there is no statistically significant difference according to gender.

Tables 3 and 4 show the postural status of the left and right foot. Based on the obtained results related to the feet, it can be concluded that the biggest problem is the lowering of the arch of the feet type II (PPLAN2) in both girls and boys. A slightly higher percentage of lowering is found in girls, 40% for the left foot, while in boys, this percentage is slightly lower and amounts to 38.7%. There is a small difference in the right foot, namely, 41.3% in girls and 38% in boys. These results may indicate that children are paying less and less attention to this problem, and certainly the motor movements and the need for

lower body CG due to the chosen sport can be the causes of this large percentage. What is satisfactory is that the percentage of the normal foot arch (BOF) is close to the lowered foot arch level II (PPLAN2), which can be a good indicator of the successful work of some coaches. These results are similar to the results of Romanov et al. (2014) as well as Mihajlović et al. (2010), which may support the claim that moving structures in karate affect the increase in the percentage of foot arch lowering. Namely, due to greater stability, by bending their knees, karate players lower the body's centre of gravity by ten centimetres. As the load is transferred to the ankles and to its inner medial part, there is pressure on the foot arch. Due to muscle weakness, the arch is lowered and deformed.

When it comes to the frequency and types of injuries among female and male karate athletes, it can be seen in Table 5 that, out of 300 respondents, 17 (5.7%) never had an injury, while the remaining 283 (94.3%) respondents experienced some of the above injuries while playing sports. The most common injury is an ankle injury with the foot and toes - 121 (40.3%) respondents. A slightly higher number of these injuries is 62 for girls (41.3%), while the number for boys is lower by 3 respondents and amounts to 59 (39.3%). The reason for the high frequency of ankle injuries with the foot and toes most likely lies primarily in the fact that specific loads appear during the moving activities themselves. Karatekas are in constant leaps, which is one of the demands of modern karate. Namely, in order to adequately prepare a kick (attack), an athlete must be prepared for a quick reaction and the moment when the opponent is reckless to deliver a kick. Only in short leaps and standing on tiptoe can one react quickly and adequately. A quick reaction requires connecting the kinetic chain into one unity, then, large and fast rotations in the ankle joint, as well as a constant change of direction and type of movement. Injuries to the metatarsal bones and toes most often occur during unwanted contact and insufficient concentration as well as sagging of the foot. Shoulder girdle injuries are in the second place when it comes to the frequency of injuries in the examined group of female and male karate athletes. The total number is 39 (13%). As in the previous injury, the number of injuries is higher in the female population - 21 (14%), while the number of boys is lower by 3, amounting to 18 (12%). The reason for such a large number of injuries is similar to the previous injury.

Moving structures in karate and giving, especially blocking punches lead to injuries that are characteristic of the shoulder girdle. The shoulder joint is the centre of rotation of the lever, i.e., hands, and each blow is transmitted to the most loaded point of the lever, which is the shoulder in this case. This speaks in favour of a well-protected joint, regardless of the fact that it has 5 different joints in its very structure. In this way, kinetic energy is "wasted" on 5 different joint surfaces, and thus slows down and cushions the blow or block during the competition itself. An additional load is the voluntary contraction when controlling the impact, and especially when performing on the floor (kata). Other injuries were injuries to the head, ribs, arms, fists, back, legs, and knees in a small percentage and totalled 160 (56.5%), excluding those who had no injuries, which is "small" for the number of injuries compared to 123 (41%) for the two largest groups of injuries - ankle with foot and toes, and shoulder girdle.

Unfortunately, injuries are an integral part of sports, but there are ways to prevent them, and certainly reduce their severity when the injury itself occurs. It is very important to keep in mind that an accurate and quick diagnosis can have an impact on the time of absence from the field, the cost of recovery and the very success of rehabilitation.

CONCLUSION

The results obtained by this research indicate that both sexes (female and male karate athletes) have a worrying percentage of deviations from the normal postural status. Looking at girls and boys and their relationships in poor posture, there are small differences in spinal deformities, but there is no statistically significant difference according to gender. The worrying results obtained in this way indicate that the health status of the study participants, namely the postural status of the spine, ankle and foot, imposes an obligation on the medical and sports profession to change the current approach to this problem in order to solve or reduce it. Additionally, the results of the research indicate that only 17 respondents did not face an injury during their short training and competition process, having in mind the fact that the population is aged 6-12 years. There are certainly more injuries that occurred in training than in competition. This is somewhat understandable because more time is spent on training, but at the same time, it points to the fact that not enough attention is paid to training for the main part of training. When it comes to experts in training technology, it is necessary for them to try to apply new training methods, primarily in order to prevent injuries. As karate is a sport of skill and technique, it requires exceptional fitness because it is directly dependent on the maximum level of strength, speed, power, balance, and agility. Therefore, special training is needed to improve performance in order to achieve success in this area, which only healthy (uninjured) karatekas can do.

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POSTURALNI STATUS I POVREDE KOD KARATISTA MLAĐE ŠKOLSKE DOBI IZ VOJVODINE

Istraživanje je provedeno na uzorku od 150 karatistkinja i 150 karatista u dobi od 6 do 12 godina tokom Prvenstva Vojvodine u Kikindi koje je organizovao KK Haiken sa preko 450 takmičara iz karate klubova Vojvodine. Predmet istraživanja se odnosio na posturalni status i povrede karatista mlađe školske dobi. Cilj istraživanja je bio utvrditi posturalni status ispitanika te povrede koje su nastale tokom treninga ili takmičenja u karateu kako bi se potencijalno primijenile nove metode treninga. Pored prikupljanja podataka mjerenjem statusa kičme, gležnja i stopala, u svrhu istraživanja je razvijen i posebni upitnik koji se odnosi na zadobijene povrede ispitanika. Ova transverzalna studija je koristila mjere deskriptivne statistike. Rezultati istraživanja ukazuju da je lordotično držanje zastupljeno sa 36% kod djevojčica te 46,7% kod dječaka, dok je kifotično držanje prisutno u znatno manjem omjeru sa 10% kod djevojčica i 8,7% kod dječaka. Luk stopala je bio 40% više izražen kod djevojčica, dok je isti bio 38,7% kod dječaka. Od ukupnog broja ispitanika, 17 (5,7%) nikada nije zadobilo povredu, dok je preostalih 283 (94,3%) pretrpilo neke povrede tokom bavljenja sportom. Dobiveni rezultati istraživanje ukazuju na potrebu za primjenom novih metoda treninga te vježbi korektivne gimnastike.

Ključne riječi: držanje, kičma, stopalo, povrede, djeca, karate

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