ISSN 1451-7485

9 771451 748001 >

ISSN 1451-7485 eISSN 2337-0351

SportMont

www.sportmont.ucg.ac.me

February 2021

VOL.19

NO.1

SportMont
ISSN 1451-7485 eISSN 2337-0351
www.sportmont.ucg.ac.me

Index Coverage
Scopus; DOAJ; SCImago; SPORTDiscus; Index Copernicus; ERIH PLUS; Open Academic Journals Index; Google Scholar; Crossref; ROAD; SHERPA/RoMEO; NLM Catalog

Proofreading Service
Terry T. Jackson

Prepress
Milicko Ceranic

Print
Art Grafika | Niksic

Print run
1500

ISSN 1451-7485 eISSN 2337-0351

SPORT MONT
International Scientific Journal

Vol. 19(2021), No.1 (1-133)

TABLE OF CONTENTS

Full-text available free of charge at http://www.sportmont.ucg.ac.me/

DOI 10.26773/smj.210201

ORIGINAL SCIENTIFIC PAPER

Association of Motor Abilities and Morphological Characteristics with Results on a Rowing Ergometer

Tomislav Sablic[1], Sime Versic[1] and Ognjen Uljevic[1]

[1]University of Split, Faculty of Kinesiology, Split, Croatia

Abstract

This study aimed to determine the association of morphological characteristics and motor abilities on the results achieved on a rowing ergometer. The participants were 36 students of Faculty of Kinesiology of the University of Split, Croatia (21 males, 15 females). The sample of variables consisted of a total of 22 variables: 11 variables measuring morphological characteristics, 10 motor abilities (predictors), and the result on a rowing ergometer. The ergometer variable represented the test result achieved on a rowing ergometer at a distance of 2000 meters. The correlation between predictors and criterion was evidenced by Pearson's product-moment correlation. A big correlation was found between rowing 2000 m on an ergometer and wall squat, stand and reach, body height, foot-tapping and calf skinfold for men; and body height and mass, calf- and mid-upper-arm-circumference, biceps-, triceps-, subscapular- and calf-skinfold, medicine ball throw and wall squat test, for women. Success in rowing is directly dependent on morphological characteristics and motor abilities. For more detailed analysis, partial influences of each factor, psychophysical characteristics, technical and tactical abilities and external influence should be taken into consideration.

Keywords: *motor abilities, morphological characteristics, ergometer, rowing*

Introduction

When the structure of the movement is taken into consideration, rowing belongs to a group of monostructural, cyclic sports, characterized by repeated movement structure (McArthur, 1997). All official rowing races are held on 2000-meters courses and, depending on the discipline, they take between five and eight minutes (FISA, 2006). Rowing can be classified as an aerobic-anaerobic sport with a dominant aerobic energy component (Hagerman, Connors, Gault, Hagerman, & Polinski, 1978; Messonnier, Freund, Bourdin, Belli, & Lacour, 1997). At the start of the race, in the initial acceleration phase, energy needs are covered primally with the anaerobic alactic mechanism; after reaching the maximum speed and in a transitional phase, the anaerobic lactic system is the primary source of energy production; after 90 seconds of the race, the key role in energy production is taken by the aerobic energy mechanism (Hagerman, 1984). In addition to the energy component, an effective rowing technique is essential for success (Secher & Volianitis, 2009).

A rowing ergometer is a specific training machine that provides a good simulation of rowing stroke on the water and comparable amount of energy expended and, therefore, is most important training content when training on water is not possible for any reason (e.g., strong wind, big waves) (Schabort, Hawley, Hopkins, & Blum, 1999). It is often used during winter, in the preparation period, and when official rowing ergometer competitions are organized by FISA or national federations (FISA, 2006). Analyses of force production and movement of the stroke found that kinematic and kinetic variables are similar for rowing in the boat on the water and on the rowing ergometer; it thus represents an accurate simulation of rowing (Lamb, 1989; Mikulić, Vučetić, Matković, & Oreb, 2005). However, given the absence of a technical component, the result on the ergometer should not be taken as the only relevant predictor of rowing performance in the boat, but rather as an indication of the individual's current state of training.

Anthropological attributes are organized systems of all characteristics, abilities, and motor information, as well as their interrelations (Breslauer, Hublin, & Zegnal Koretić, 2014). Among

Correspondence:

S. Versic
University of Split, Faculty of Kinesiology, Teslina 6, 21000 Split, Croatia
E-mail: simeversic@gmail.com

others, morphological characteristics and motor abilities are parts of the anthropological status of each human being; their relationship to success in sport is a matter of interest to many researchers (Gardasevic et al., 2020; Krstulovic, Males, Zuvela, Erceg, & Miletic, 2010; Trninić, Jelaska, & Papić, 2009). Research studies done on rowers have shown that aerobic and anaerobic capacities, the strength of lower extremities, body mass and height are good predictors of rowing success (Claessens et al., 2005; Jürimäe et al., 2010; Secher, 1975).

Since, to author's knowledge, all of the studies done on this subject evaluate the performance of active rowers, this research aimed to determine the association of morphological characteristics and motor abilities on the results achieved in the test on a rowing ergometer at a distance of 2000 meters on a sample of students that have no previous experience in rowing.

Methods

Participants in this study were 36 students (21 men and 15 women) of third-year undergraduate study. During the eight-week course, students learned the technique of rowing on an ergometer and prepared physically for the final test of 2000 meters, which was part of their exam. All participants were clinically healthy at the time of testing.

The set of variables consisted of 11 variables of morphological characteristics, 10 variables of motor abilities, and the test of rowing on an ergometer for 2000 meters. The measured morphological characteristics were: body height, body weight, circumference of the upper arm in flexion, circumference of the lower leg, diameter of the elbow, diameter of the knee, biceps skinfold, triceps skinfold, scapular skinfold, abdominal skinfold and calf skinfold. All measures were taken on the dominant side of the body, were measured three times, and the arithmetic mean was taken as the final result. Motor abilities were measured with the following test: hand taping, leg tapping, broad jump, sitting medicine throw, pullups, sit-ups, rowing bar pull, Biering-Sorensen, wall squat and standing flexibility. Hand taping, leg tapping, broad jump, sitting medicine throw, and standing flexibility tests were measured three times, and the best results were taken as final, while pullups, sit-ups, rowing bar pull, Biering-Sorensen, and wall squat were taken only once because of the fatigue factor.

All testing was held in the Gusar Rowing Club for two days, as ergometer rowing was held on the first day and all other tests on the second day. Considering that higher grades in the course required better performance on the ergometer, we can assume that the motivation factor contributed to the "situational-competitive" conditions.

In statistical analysis, the descriptive statistics included the means and standard deviations presented as the true results for each variable, and the Kolmogorov-Smirnov test was used for testing normality of distribution. To identify the univariate associations between ergometer variable and morphological and motoric variables, Pearson's product-moment correlation was calculated. For all analyses, Statistica 13.0 (TIBCO Software Inc, USA) was used, and a p-level of 95% was applied.

Results

The Kolmogorov-Smirnov test (Table 1) showed that variables broad jump and wall squat for men and pull ups and diameter of the elbow for women are not normally distributed, while all other variables have normal distribution. The most significant variability was found for sitting medicine throw and wall squat for men and Biering-Sorensen for women.

Table 1. Descriptive parameters

Variables	Men (n=21) M±SD	Women (n=15) M±SD	Kolmogorov-Smirnov test
hand taping	46.81±5.78	47.13±3.72	0.15
leg tapping	29.19±3.22	28.80±4.25	0.13
broad jump	236.67±19.70	187.67±16.37	0.09
sitting medicine throw	460.34±52.49	342.73±35.96	0.07
pull ups	13.71±4.45	1.13±2.53	0.19
sit ups	53.00±6.39	49.93±6.22	0.12
rowing bar pull	18.33±4.72	22.87±7.80	0.13
Biering-Sorensen	102.52±27.18	146.40±62.89	0.15
wall squat WS	86.09±47.78	80.73±30.57	0.13
standing flexibility	22.19±7.66	30.87±4.21	0.09
body height	180.21±6.87	170.17±6.31	0.09
body weight	77.68±7.94	64.71±8.84	0.12
circumference of the upper arm in flexion	35.24±2.62	29.59±2.08	0.07
circumference of the lower leg	38.41±3.08	37.07±2.43	0.12
diameter of the elbow	6.81±0.38	6.42±0.97	0.16
diameter of the knee	8.98±0.48	8.57±0.91	0.15
biceps skinfold	3.92±0.79	7.44±2.62	0.24
triceps skinfold	8.64±2.35	15.71±3.71	0.11
scapular skinfold	9.89±1.99	13.76±4.15	0.17
abdominal skinfold	4.52±0.99	8.97±3.56	0.22
calf skinfold	6.73±1.96	15.37±4.19	0.18
rowing 2000 m on ergometer	436.42±17.51	514.83±25.28	0.17

Results of correlation analysis (Table 2) showed big correlations between rowing on ergometer and wall squat, standing flexibility, body height, leg tapping and calf skinfold for men and sitting medicine throw, wall squat, body height, body weight, circumference of the upper arm in flexion, circumference of the lower leg, biceps skinfold, triceps skinfold, scapular skinfold, abdominal skinfold and calf skinfold for women.

Table 2. Correlation matrix (Pearson's product-moment correlation)

Variables	Men	Women
	rowing 2000 m on ergometer	
hand taping	-0.31	0.24
leg tapping	-0.45	-0.36
broad jump	-0.26	-0.23
sitting medicine throw	0.01	-0.67
pull ups	-0.37	0.14
sit ups	-0.25	-0.13
rowing bar pull	-0.03	-0.37
Biering-Sorensen	-0.23	-0.01
wall squat	-0.58	-0.62
standing flexibility	-0.55	0.33
body height	-0.46	-0.63
body weight	-0.41	-0.92
circumference of the upper arm in flexion	0.01	-0.68
circumference of the lower leg	-0.26	-0.75
diameter of the elbow	-0.04	-0.18
diameter of the knee	0.29	-0.26
biceps skinfold	-0.18	-0.51
triceps skinfold	0.07	-0.68
scapular skinfold	0.18	-0.56
abdominal skinfold	-0.31	-0.45
calf skinfold	-0.45	-0.56

Discussion

Men

The wall squat test is a measure of the isometric endurance of the lower leg muscles (Lubans et al., 2011). More stamina and strength in muscles can produce larger amounts of force, which can be transported in every stroke; research has shown that rowers with stronger legs have better results in races and on the ergometer (Jürimäe et al., 2010; Lawton, 2012). The correlation between the results on the wall squat test and the rowing 2000 m on ergometer can also be explained by the psychological aspect since the motivation to do the test at the maximum level can strongly affect the outcome (Marinović, 1990). A big correlation for men was also found for the test of standing flexibility, with which the flexibility of the posterior part of the body, mostly the lumbar spine and the hamstring muscles, was measured. Optimal flexibility of these muscles enables better body position of rower in the relaxing phase of the stroke and better preparation to generate more force in the propulsive phase (Kleshnev, 2016). Also, decreased flexibility of back and leg muscles can cause injuries because at the beginning of the stroke tense muscles pull the pelvis and increase flexion in lumbal part (Šimić, 2015). The leg tapping test was measured to show the speed of movement frequency of the lower extremities. Movement frequency velocity as a motor ability is defined by performing repetitive movements of constant amplitude as fast as possible (Sekulić, 2007). Considering that the high tempo of the strokes contributes to the speed of the boat, it is easy to conclude that maintaining a constant high speed of movement requires a constant high number of strokes, which in race races reaches an average of 40 strokes per minute (Kleshnev, 2016).

The influence of body height on rowing performance has been explored in numerous studies as the longitudinal dimensionality (length of extremities) has been noted as one of the most important predictors of rowing success (Bourgois et al., 2000; Bourgois & Vrijens, 2001; Claessens et al., 2005; Mikulić, 2008). Since the participants in this study were students, the correlation was smaller than in previously cited studies done on rowers but was also big. The association with results on the rowing 2000 m on ergometer was also found for the variable of skinfold measured on the calves. Successful rowers, runners, and cyclists are characterized by above-average percentages of Type I (slow) muscle fibres in the leg, with measured values up to 85% (Seiler, 2003). Although it is a general assumption that adipose tissue has a negative impact on performance (Jurov et al., 2020), researchers have identified, in a group of runners, high positive relation of quadriceps and calf skinfold and time on 1500 and 10,000 meters so it can be a useful predictor of athletic achievement in the previously mentioned endurance athletes (Arrese & Ostáriz, 2006).

Women

On a sample of female students, big correlations were found for most of the morphological variables and for wall squat and sitting medicine throw test. The relationship between wall squat test and results of 2000 metres on that rowing ergometer has already been explained on a sample of male students. Sitting medicine throw test is a measure of the explosive power of the upper body (Stockbrugger & Haennel, 2001). Although that segment of motor abilities is not of high importance for rowing success (Jürimäe et al., 2010), we can assume that the results of this test is associated by the higher amount of muscle mass in the upper body which also positively affects the results on the ergometer (Bourgois et al., 2000).

Confirmation of that finding can be seen by looking at correlations with morphological variables for which big negative relations were identified for body weight, body height, both circumferences (upper arm in flexion and lower leg) and all skin folds (biceps, triceps, abdominal, scapular and calf). Active muscular body mass is of great importance for rowing because of the possibility of generating greater force, which with longitudinal dimensionality creates the conditions for a longer stroke, greater propulsive force and greater speed of movement (Claessens et al., 2005). The term "body mass" does not reveal much because the amounts of muscle mass and adipose tissue in the total body mass are unknown. However, since ballast does not have a negative effect rowing on an ergometer, as would be the case with rowing on a rowing boat (Nevill, Beech, Holder, & Wyon, 2010), increased body mass can be seen primarily as a mechanism for achieving a stronger stroke force.

The findings of this study, although investigated on a sample of non-rowers, confirmed conclusions of previous similar studies which stated that the success in rowing, both in the boat and on the ergometer, depends directly on the morphological characteristics and motor skills.

However, for a more detailed analysis of "multidimensional" performance, it must be viewed through the specification equation, while analysing the partial impact of each factor, psychophysical characteristics, technical and tactical abilities and external influences individually.

The results of the conducted research will provide information for future research according to which researchers will be able to search for morphological, motor and psychosocial and other factors that define sports performance.

Acknowledgements
There are no acknowledgements.

Conflict of Interest
The authors declare the absence of conflict of interest.

Received: 14 March 2020 | **Accepted:** 25 May 2020 | **Published:** 01 February 2021

References

Arrese, A. L., & Ostáriz, E. S. (2006). Skinfold thicknesses associated with distance running performance in highly trained runners. *Journal of sports sciences, 24*(1), 69-76.

Bourgois, J., Claessens, A. L., Vrijens, J., Philippaerts, R., Van Renterghem, B., Thomis, M., . . . Lefevre, J. (2000). Anthropometric characteristics of elite male junior rowers. *British journal of sports medicine, 34*(3), 213-216.

Bourgois, J., & Vrijens, J. (2001). *Growth, maturation and development: consequences for a long-term build-up training programme in rowing.* Paper presented at the W. Fritsch (Hrsg.): Rudern-Entwickeln, Kooperieren, Vermitteln, Berichtsband zum 4. Konstanzer Rudersymposium, Sindelfingen, Sportverlag, Schmidt & Dreisilker GmbH.

Breslauer, N., Hublin, T., & Zegnal Koretić, M. (2014). *Basics of Kineziology*. Handbook for students of professional study of Tourism and Sports Management [Osnove kineziologije. Priručnik za studente stručnog studija Menađmenta turizma i sporta].

Claessens, A. L., Bourgois, J., Van Aken, K., Van der Auwera, R., Philippaerts, R., Thomis, M., Lefevre, J. (2005). Body proportions of elite male junior rowers in relation to competition level, rowing style and boat type. *Kinesiology, 37*(2), 123-132.

FISA. (2006). FISA Rules of Racing.

Gardasevic, J., Bjelica, D., Vasiljevic, I., Corluka, M., Arifi, F., & Sermaxhaj, S. (2020). Morphological characteristics and body composition of the winners of the soccer cup of Bosnia and Herzegovina and Kosovo. *Sport Mont, 18(1),* 103-105.

Hagerman, F., Connors, M., Gault, J., Hagerman, G., & Polinski, W. (1978). Energy expenditure during simulated rowing. *Journal of applied physiology, 45*(1), 87-93.

Hagerman, F. C. (1984). Applied physiology of rowing. *Sports medicine, 1*(4), 303-326.

Jürimäe, T., Perez-Turpin, J. A., Cortell-Tormo, J. M., Chinchilla-Mira, I. J., Cejuela-Anta, R., Mäestu, J., ... Jürimäe, J. (2010). Relationship between rowing ergometer performance and physiological responses to upper and lower body exercises in rowers. *Journal of science and medicine in sport, 13*(4), 434-437.

Jurov, I., Milic, R., & Rauter, S. (2020). Do Body Composition and Physiological Parameters Measured in the Laboratory Have Predictive Value for Cycling Performance? *Sport Mont, 18*(1)*,* 87-90.

Kleshnev, V. (2016). *Biomechanics of rowing*: The Crowood Press.

Krstulovic, S., Males, B., Zuvela, F., Erceg, M., & Miletic, D. (2010). Judo, soccer and track-and-field differential effects on some anthropological characteristics in seven-year-old boys. *Kinesiology, 42*(1), 56-64.

Lamb, D. H. (1989). A kinematic comparison of ergometer and on-water rowing. *The American journal of sports medicine, 17*(3), 367-373.

Lawton, T. W. (2012). *Strength testing and training of elite rowers.* Auckland University of Technology,

Lubans, D. R., Morgan, P., Callister, R., Plotnikoff, R. C., Eather, N., Riley, N., & Smith, C. J. (2011). Test–retest reliability of a battery of field-based health-related fitness measures for adolescents. *Journal of sports sciences, 29*(7), 685-693.

Marinović, M. (1990). Relationship between general motor skills and conative characteristics with success in working on a rowing ergometer [Povezanost općih motoričkih sposobnosti i konativnih karakteristika s uspješnošću u radu na veslačkom ergometru]. *Kineziologija, 22*, 39-44.

McArthur, J. (1997). *High performance rowing*: Crowood Press.

Messonnier, L., Freund, H., Bourdin, M., Belli, A., & Lacour, J.-R. (1997). Lactate exchange and removal abilities in rowing performance. *Medicine & Science in Sports & Exercise, 29*(3), 396-401.

Mikulić, P. (2008). Anthropometric and physiological profile of rowers of different ages and qualitative levels [Antropometrijski i fiziološki profil veslača različite dobi i kvalitativne razine]. *Kinesiology: International journal of fundamental and applied kinesiology, 40*(1), 80-88.

Nevill, A. M., Beech, C., Holder, R. L., & Wyon, M. (2010). Scaling concept II rowing ergometer performance for differences in body mass to better reflect rowing in water. *Scandinavian journal of medicine & science in sports, 20*(1), 122-127.

Schabort, E., Hawley, J., Hopkins, W., & Blum, H. (1999). High reliability of performance of well-trained rowers on a rowing ergometer. *Journal of sports sciences, 17*(8), 627-632.

Secher, N. H. (1975). Isometric rowing strength of experienced and inexperienced oarsmen. *Medicine and science in sports, 7*(4), 280-283.

Secher, N. H., & Volianitis, S. (2009). *The Handbook of Sports Medicine and Science: Rowing*: John Wiley & Sons.

Seiler, S. (2003) Training characteristics of competitive masters rowers: influence of performance history, age, and gender. *Medicine & Science in Sports & Exercise, 35*(5), S62.

Sekulić, D. M. D. (2007). The basics of transformation processes in kinesiology. *Faculty of Natural Sciences and Mathematics and Kinesiology*.

Stockbrugger, B. A., & Haennel, R. G. (2001). Validity and reliability of a medicine ball explosive power test. *The Journal of Strength & Conditioning Research, 15*(4), 431-438.

Šimić, B. (2015). *Prevention of back injuries in rowing* [*Prevencija ozljeda leđa u veslanju*]. University of Zagreb. Faculty of Kinesiology. Department of Kinesiologi.

Trninić, S., Jelaska, I., & Papić, V. (2009). Kinesiological, anthropological, and methodological aspects of efficacy equation in team sports games. *Acta kinesiologica, 3*(2), 7-18.

DOI 10.26773/smj.210203

ORIGINAL SCIENTIFIC PAPER

Effects of Gender on Oxygen Saturation of Thigh Muscles during Maximal Treadmill Exercise Testing

María-José Paredes-Ruiz[1], María Jódar-Reverte[1], Ignacio Martinez González –Moro[1] and Vicente Ferrer-López[1]

[1]University of Murcia, University Institute for Research in Aging, Physical Exercise and Human Performance, Murcia, Spain

Abstract

Currently, muscle activity can be assessed by oxygen muscle saturation (SmO_2) measured with near-infrared spectroscopy (NIRS), which is a non-invasive technique that can be used in training planning and control, but more needs to be known about it. To analyse gender differences in the SmO_2 of quadriceps and hamstrings, in several phases of a maximum stress test. A total of 20 subjects, with an average age of 21 years (10 males and 10 females), were the subjects of maximal treadmill exercise testing. We obtained maximum oxygen consumption (Metalyzer 3B) and monitored the electrocardiogram continuously. In addition, we measured the SmO_2 of quadriceps and hamstrings in rest (R), start decline (D) and maximum effort (M), with two Humon Hex devices, one placed on the anterior side of the thigh and another on the back. Quadriceps SmO_2 in males: R=59.4±11.5%; D=48.3±19.1%; M=52.5±13%. Quadriceps SmO_2 in women: R=51±11.5%; D=48.5±9.4%; M=43.1±6.9%. Hamstrings SmO_2 in males: R=56.2±13.1%; D=62.9±9.1%; M=57.5±13.9%. Hamstrings SmO_2 in women R=56.9±18.9%; D=49.7±7.4%; M=38.2±14.6%. There are no significant differences between muscles. There are only significant differences in M in hamstrings (p-0.009). SmO_2 during treadmill exercise is similar in both sexes, but the overall decrease with maximum exercise is greater in women's hamstrings.

Keywords: *near-infrared spectrometry, quadriceps, oxygen consumption, exercise*

Introduction

Muscle oxygen saturation (SmO_2) is a specific measure used to determine the percentage of oxygen that is captured by muscle tissue in oxidative metabolism, in order to obtain energy (Inglis, Iannetta, & Murias, 2019). Currently, SmO_2 can be determined thanks to near-infrared spectrometry (NIRS) (Farzam, Starkweather, & Franceschini, 2018).

NIRS devices have a safe and non-invasive mechanism that report the degree of participation of a specific muscle during activity. This device provides information about the muscular activity through an APP, which can be used to plan a muscular activity and training control (Grassi & Quaresima, 2016). Its management in sports practice is simple since it has a wireless design and is easy to apply in any field (Koga et al., 2015).

Furthermore, in much of the bibliography regarding the NIRS, differences in SmO_2 between men and women during physical exercise have not been studied. Generally, they have focused on the adult male sports population, and there are hardly any studies on women (Louvaris et al., 2018; Jones & Cooper, 2018; Baláš, Kodejška, & Krupková, 2018).

In contrast, various studies have related the SmO_2 of different muscles, but without considering the relationship between antagonists. Contreras-Briceño et al. (2019) observed the different levels of oxygenation of the intercostal musculature and the large lateral muscle. Others have studied the erector muscles of the lumbar spine and soleus (Chambers, Haney, Huppert, & Redfern, 2019). Another

Correspondence:

M. J. Paredes-Ruiz
University of Murcia, Campus Health Sciences, Avda. Buenavista s/n. El Palmar 30120 – Murcia, Spain
E-mail: maria.paredes1@um.es

comparison was between the twins and the superficial flexor of the fingers (Lagerwaard, Keijer, McCully, de Boer, & Nieuwenhuizen, 2019).

Most studies have used a single device, generally arranged in quadriceps (Saito, Goda, Yamagishi, & Kawakami, 2018; McLean, Kerhervé, Lovell, Gorman, & Solomon, 2016; Spencer, Amano, Kondo, Kowalchuk, & Koga, 2014). Therefore, it is interesting to know how the antagonistic muscles respond to the same activity.

Other authors have compared SmO_2, paying attention to different groups according to their sports activity, for example, between athletes and non-athletes (Clark et al., 2019; Jones & Cooper, 2018) or cyclists and non-cyclists (Crum, O'Connor, Van Loo, Valckx, & Stannard, 2017; Saito et al., 2018). Other works have been carried out to analyse the influence of obesity versus overweight (Vasquez-Bonilla et al., 2017; Soares, Reimer, Alenezi, Doyle-Baker, & Murias, 2018).

Given the scarcity of existing scientific literature on the NIRS, our study arises from the need to provide basic data on muscle oxygenation, taking into account the influence of gender and its impact on antagonist muscles.

To analyse gender differences in SmO_2 of quadriceps and hamstrings, in several phases of a maximum stress test.

Methods

A total of 20 students from the University of Murcia, with an average age of 21.9±1.6 years old were included in our work: 10 males and 10 females. The inclusive criteria were to be between 20 and 30 years old and not presenting injuries or defects that prevent the exercise test from being carried out.

The study was carried out in accordance with the Declaration of Helsinki and was approved by the Research Ethics Commission of the University of Murcia. All the participants signed the corresponding informed consent document.

All of them performed a maximum stress test on the treadmill (model run7411) with a continuous and progressive ramp protocol (1% slope). Testing started at 7 km/h with increments of 0.1 km/h every 6 seconds, with a warm-up phase of 2 minutes at 6 km/h. From it, the maximum oxygen consumption was obtained (Metalyzer 3b).

Prior to the start of the stress test, a cardiovascular examination was performed at rest. With the patient in a supine position, cardiac auscultation, blood pressure, and electrocardiogram were performed. Subsequently, the electrodes kept recording throughout the stress test. In addition, two Humon Hex® devices were placed, one on the anterior aspect of the right thigh (quadriceps) and the other on the posterior aspect of the left side (hamstrings). Each was synchronized with a Samsung Tablet connected to the corresponding APP, to visualize the information of the SmO_2, the exercise time and the heart rate. The SmO_2 of quadriceps and hamstrings at rest (R); at the beginning decline (D) and in maximum effort (M) were obtained by the SmO_2 / time graphs.

The test ends when the subject is exhausted and gestures with his hand to start the recovery phase at 3 km/h for 3 minutes and at rest for another 2 minutes. The tests were considered to be maximum and valid when they exceeded 85% of the theoretical maximum heart rate (220-age), and the respiratory quotient was greater than 1.15 (Howley, Bassett, & Welch, 1995). Finally, an active recovery period of 4 minutes at 4 km/h was carried out.

The data were analysed with the Statistical Package for Social Science (SPSS v.24). The quantitative variables have been described with the mean and standard deviation, and the qualitative ones with the absolute frequency and relative frequency. Comparison of the means of independent inter-group variables (men and women) was performed using the t-student test, and the comparison of the means of related variables was made with the t-paired test. The relationship between variables was studied using the Pearson Test. A minimum level of significance of $p<0.05$ was established.

Results

In Table 1, the basic characteristics of the population sorted by gender and the significance of their differences are shown.

Table 1. Anthropometric characteristics, according to gender

Characteristics	Gender	M±SD	p
Age (years)	Male	21.90±1.60	0.142
	Female	21.00±0.94	
Height (cm)	Male	173.51±5.68	0.000
	Female	160.30±4.80	
Weight (kg)	Male	67.52±8.42	0.018
	Female	58.48±7.06	
BMI (kg/m^2)	Male	22.37±2.05	0.712
	Female	22.80±2.92	
Girth of the thigh (cm)	Male	48.00±3.50	0.952
	Female	48.10±3.81	
Fold of the thigh (mm)	Male	20.90±7.02	0.000
	Female	33.80±6.30	

The saturation of both muscles in the three phases of exercise, separated by gender, is shown in Table 2. It is observed that there are only significant differences between men and women in the hamstring values in maximum exercise.

Table 2. Muscle saturation in each situation, muscle and gender

SmO_2	Muscle	Gender	N	M±SD	p
In rest (R)	Quadriceps	Males	10	59.40±11.58	0.121
		Females	10	51.00±11.51	
	Hamstrings	Males	10	56.20±13.15	0.925
		Females	10	56.90±18.96	
The beginning decline (D)	Quadriceps	Males	8	48.39±19.11	0.982
		Females	8	48.56±9.48	
	Hamstrings	Males	7	62.99±9.13	0.060
		Females	7	49.77±7.46	
In maximum effort (M)	Quadriceps	Males	9	52.56±13.00	0.193
		Females	10	43.10±16.91	
	Hamstrings	Males	9	57.56±13.94	0.009
		Females	10	38.20±14.61	

When the population is analysed as a whole, it is observed that there are no significant differences in the SmO_2 in the quadriceps versus the hamstrings in any of the three situations studied (Table 3).

The correlations between SmO_2 values and anthropometric variables show that the fold of the thigh is negatively correlated with the saturations of both muscles at the time of maximum effort; likewise, the girth of the thigh also does it with the SmO_2 of the hamstrings (Table 4).

Table 3. Differences in the SmO_2 between muscles in the population as a whole

SmO_2	Muscle	N	M±SD	p
In rest (R)	Quadriceps	20.00	55.20±12.03	0.774
	Hamstring	20.00	56.55±15.88	
The beginning decline (D)	Quadriceps	9.00	45.31±16.70	0.098
	Hamstring	9.00	57.89±10.39	
In maximum effort (M)	Quadriceps	19.00	47.58±15.54	0.966
	Hamstring	19.00	47.37±17.08	

Table 4. Correlations between anthropometric variables and SmO_2

		In Rest		Beginning of Decline		In Maximum Effort	
		Q	H	Q	H	Q	H
Age (years)	Pearson	0.091	-0.237	-0.589	0.243	0.367	0.222
	Sig.	0.703	0.315	0.016	0.500	0.122	0.362
	N	20	20	16	10	19	19
Height (cm)	Pearson	0.474	-0.005	0.126	0.380	0.409	0.230
	Sig.	0.035	0.985	0.641	0.278	0.082	0.344
	N	20	20	16	10	19	19
Weight (kg)	Pearson	0.219	-0.155	0.079	-0.140	0.289	-0.209
	Sig.	0.354	0.514	0.772	0.700	0.229	0.390
	N	20	20	16	10	19	19
BMI (kg/m²)	Pearson	-0.197	-0.198	-0.019	-0.559	-0.015	-0.457
	Sig.	0.405	0.402	0.945	0.093	0.951	0.049
	N	20	20	16	10	19	19
Girth of the thigh (cm)	Pearson	-0.086	-0.170	0.071	-0.439	0.141	-0.479
	Sig.	0.717	0.474	0.795	0.204	0.563	0.038
	N	20	20	16	10	19	19
Fold of the thigh (cm)	Pearson	-0.213	-0.033	0.199	-0.479	-0.638	-0.525
	Sig.	0.366	0.891	0.460	0.161	0.003	0.021
	N	20	20	16	10	19	19

Discussion

The objective of the present study was to analyse the differences between the genders of the SmO_2 of the quadriceps and hamstring muscles in various phases of a maximal stress test, in a total of 20 subjects. Other authors, such as Vitorio et al. (2018) and Born, Stöggl, Swarén and Björklund (2017) used a similar number to determine if there are effects of rhythmic auditory signals during gait on cortical activation and cognitive function or whether heart rate or tissue saturation is affected by the continuous change of intensity in the exercise.

We have focused this work on the analysis of the main antagonist muscles present in the race, comparing SmO_2 between the quadriceps and hamstrings of the subjects as a whole, in which no significant differences were obtained in any of the three phases. Therefore, we cannot compare these results with other works, since we did not find in the available literature any study involving these muscle; most studies are focused on the quadriceps (e.g. Saito et al., 2018; McLean et al., 2016).

The results obtained indicated that men have higher SmO_2 values in the hamstrings than women during the maximum exercise phase. In contrast, most of the consulted papers (Contreras-Briceño et al., 2019; Louvaris et al., 2018; Jones, & Cooper, 2018) only evaluated SmO_2 in men. Therefore, it is difficult to determine if there are differences in relation to gender.

We evaluated SmO_2 analysis during three different phases: rest, the onset of decline, and the highest point of exercise. In contrast, different studies evaluated SmO_2 at the maximum peak of exercise intensity (Koga et al., 2015; Contreras-Briceño et al., 2019) or, to a lesser extent, this is combined with the measurements at rest (Inglis et al., 2019; Louvaris et al., 2018).

Furthermore, a relationship between anthropometric measurements and oxygen saturation has been sought. Both the fold and the girth of the thigh have shown a negative relationship with SmO_2 at the moment of maximum effort, that is people with a higher fat content have lower SmO_2 values. In previous studies (Quaresima et al., 2003; Vasquez-Bonilla et al., 2017) it was seen that women generally have a greater layer of subcutaneous fat, which can cause interference in the receptor signal and decrease the reliability.

The stress test was carried out on a treadmill with an incremental ramp protocol; because it is one of the most widely used protocols and allows reaching the maximum effort of the athlete in a relatively short time (Boone & Bourgois, 2012). Despite this, most of the works related to the NIRS have used the cyclo-algometer, using an incremental cycling test in a laboratory (Koga et al., 2015; Saito et al., 2018). Therefore, because they are two different evaluation tests with opposite sports gestures, it is not appropriate to make comparisons.

Regarding the limitations of this study, our subjects are amateur athletes who present a very similar physical condition; therefore, since we do not have highly trained subjects, we cannot assure that our SmO_2 values are representative of other populations. Despite this, the values obtained can serve as a basis for the study of this sort of population.

NIRS-based technology could be used to improve athlete performance in a non-invasive and safe manner, aiding in planning the training according to the physiological characteristics and physical condition of each subject. Also, it is a way of keeping track of muscle oxygenation and helping to set short and medium-term goals aimed at improving performance in physical exercise.

We conclude that the oxygen saturation of the hamstrings at maximum effort is different between men and women, while there are no differences in the other phases of exercise. Likewise, there are no differences in oxygenation between both muscles. However, a negative correlation appears with the anthropometric measurements of the thigh, that is, the higher the percentage of subcutaneous fat in the thigh, the lower SmO2.

Acknowledgements
There are no acknowledgements.

Conflict of Interest
The authors declare the absence of conflict of interest.

Received: 15 March 2020 | **Accepted:** 10 May 2020 | **Published:** 01 February 2021

References

Baláš, J., Kodejška, J., Krupková, D., Hannsmann, J., & Fryer, S. (2018). Reliability of Near-Infrared Spectroscopy for Measuring Intermittent Handgrip Contractions in Sport Climbers. *Journal of Applied Sport Science Research*, *32*(2), 494–501.

Boone, J., & Bourgois, J. (2012). The oxygen uptake response to incremental ramp exercise: methodogical and physiological issues. *Sports Medicine, 42*(6), 511-526.

Born, D. P., Stöggl, T., Swarén, M., & Björklund, G. (2017). Near-Infrared Spectroscopy: More accurate than heart rate for monitoring intensity in running in hilly terrain. *International journal of sports physiology and performance, 12*(4), 440-447.

Chambers, A. J., Haney, J. M., Huppert, T., & Redfern, M. S. (2019). The effect of prolonged walking with intermittent standing on erector spinae and soleus muscle oxygenation and discomfort. *Montenegrin journal of sports science and medicine, 18*(2), 337-343.

Clark, I. E., Goulding, R. P., DiMenna, F. J., Bailey, S. J., Jones, M. I., Fulford J., . . . Vanhatalo A. (2019). Time-trial performance is not impaired in either competitive athletes or untrained individuals following a prolonged cognitive task. *European journal of applied physiology, 119*(1), 149-161.

Contreras-Briceño, F., Espinosa-Ramirez M., Hevia G., Llambias D., Carrasco, M., Cerda F., . . . López-Fuenzalida, A. (2019). Reliability of NIRS portable device for measuring intercostal muscles oxygenation during exercise. *Journal of sports sciences, 37*(23), 2653-2659.

Crum, E. M., O'Connor, W. J., Van Loo, L., Valckx, M., & Stannard, S. R. (2017). Validity and reliability of the Moxy oxygen monitor during incremental cycling exercise. *European Journal of Sport Science, 17*(8), 1037-1043.

Farzam, P., Starkweather, Z., & Franceschini, M. (2018). Validation of a nobel wearable, wiriless techonology to estimate oxigen levels and lactate threshold power in the exercising muscle. *Physiological Reports*, *6*(7), 1-14.

Grassi, B., & Quaresima V. (2016). Near-infrared spectroscopy and skeletal muscle oxidative function in vivo in health and disease: a review from an exercise physiology perspective. *Journal of Biomedical Optics*, *21*(9), 91313-91320.

Howley, E. T., Bassett, D. R., & Welch, H. G. (1995). Criteria for maximal oxygen uptake: review and commentary. *Medicine and science in sports and exercise, 27*(1), 1292-1292.

Inglis, E. C., Iannetta, D., & Murias, J. M. (2019). Evaluating the NIRS-derived microvascular O2 extraction "reserve" in groups varying in sex and training status using leg blood flow occlusions. *Public Library of Science*, *14*(7), 1-33.

Jones, B., Cooper, C.E. (2018). Near Infrared Spectroscopy (NIRS) observation of vastus lateralis (muscle) and prefrontal cortex (brain) tissue oxygenation during synchronised swimming routines in elite athletes. *Advances in Experimental Medicine and Biology*, 1072, 111-117.

Koga, S., Barstow, T. J., Okushima, D, Rossiter, H. B., Kondo, N, Ohmae, E., . . . Poole D. C. (2015). Validation of a high-power, time-resolved, near-infrared spectroscopy system for measurement of superficial and deep muscle deoxygenation during exercise. *European Journal of Applied Physiology*, *118*(11), 1435-1442.

Lagerwaard, B., Keijer, J., McCully, K., de Boer, V., & Nieuwenhuizen, A. G. (2019). In vivo assessment of muscle mitochondrial function in healthy, young males in relation to parameters of aerobic fitness. *European journal of applied physiology, 119*(8), 1799–1808.

Louvaris, Z., Habazettl, H., Wagner, H., Zakynthinos, S., Wagner, P., & Vogiatzis I. (2018). Near-infrared spectroscopy using indocyanine green dye for minimally invasive measurement of respiratory and leg muscle blood flow in patients with COPD. *European Journal of Applied Physiology*, *125*(3), 947-959.

McLean S., Kerhervé, H., Lovell, G. P., Gorman, A. D., & Solomon, C. (2016). The effect of recovery duration on vastus lateralis oxygenation, heart rate, perceived exertion and time motion descriptors during small sided football games. *Public Library of Science*, *11*(2), 1-17.

Saito, A., Goda, M., Yamagishi, T., & Kawakami Y. (2018). Riding posture affects quadriceps femoris oxygenation during an incremental cycle exercise in cycle-based athletes. *Physiological Reports*, *6*(16), 1-7.

Soares, R. N., Reimer, R. A., Alenezi, Z., Doyle-Baker, P. K., & Murias, J. M. (2018). Near-infrared spectroscopy can detect differences in vascular responsiveness to a hyperglycaemic challenge in individuals with obesity compared to normal-weight individuals. *Diabetes and Vascular Disease Research*, *15*(1), 55-63.

Spencer, M. D., Amano, T., Kondo, N., Kowalchuk, J. M., & Koga, S. (2014). Muscle O2 extraction reserve during intense cycling is site-specific. *European Journal of Applied Physiology*, *117*(10), 1199-1206.

Quaresima V., Lepanto R., & Ferrari M. (2003). The use of near infrared spectroscopy in sports medicine. *The Journal of sports medicine and fitness, 43*(1), 1-13.

Vasquez-Bonilla, A., Camacho-Cardeñosa, A., Camacho-Cardeñosa, M., Martínez-Guardado, I., Timón, R., & Olcina, G. (2017). Evaluación de parámetros fisiológicos en función de la saturación de oxigeno muscular en mujeres con sobrepeso y obesidad. *International journal of sport science*, *13*(47), 63-77.

Vitorio, R., Stuart, S., Gobbi, L. T. B., Rochester, L., Alcock, L., & Pantall, A. (2018). reduced gait variability and enhanced brain activity in older adults with auditory cues: A Functional Near-Infrared Spectroscopy Study. *Neurorehabilitation and neural repair, 32*(11), 976–987.

DOI 10.26773/smj.210205

SportMont

ORIGINAL SCIENTIFIC PAPER

Factors Leading to Goal Scoring in the Spanish and Italian Soccer Leagues

Savvas Papadopoulos[1], Katerina Papadimitriou[1], Xanthi Konstantinidou[1], Ourania Matsouka[1], Georgios Pafis[1] and Dimitris Papadopoulos[1]

[1]Democritus University of Thrace, Department of Physical Education and Sport Science, Komotini, Greece

Abstract

The purpose of this study was to analyse the goal-scoring attacks made by the top four teams in the final standings of the Spanish and Italian 2017–2018 Football League tables. One of the objectives of the study was to compare the match behaviours leading to goal scoring, demonstrated by the aforementioned teams. The sample of the study comprised 606 goals, 316 scored in the Spanish League and 290 in the Italian League, and 280 matches. The phases were recorded using the SportScout coaching tool. The studied parameters were: time frame in which the goals were scored, type of final attempt, type of play that resulted in a goal, type of attack, mode of set play, goal-scoring zone, zone of the final pass, starting zone of the attack, and number of passes. The data were statistically processed using the Crosstabs analysis and the Chi-square significance test. The results showed that the two leagues differed in the type of attack and in the offensive zone. The observed differences were possibly due to the different approach to the game in the two leagues, with the Spanish teams relying more on organized combination play, while the Italians showed a greater diversity in their offensive play.

Keywords: *offensive tactics, elite leagues, video analysis*

Introduction

In general, performance in football depends on several factors, such as technique, tactics, as well as the mental and physical fitness of the players (Stolen, Chamari, Castagna, & Wisloff, 2005). As far as in-game behaviour is concerned, the game analysis relies on objective observation and the recording and evaluation of technical-tactical actions occurring during a match. The result of these actions (a complete attack that may or may not result in goal scoring) can delineate the playing strategy of the team (Carling, Williams, & Reilly, 2005). However, it has been known for many years that a goal may lead to a radical shift in a team's tactical play, depending on the impact it has on the final score (Palomino, Rigotti, & Rustichini, 1998).

Moreover, some studies highlight the link between goal scoring and factors, such as the number of shots taken in relation to the number of passes during each ball possession, and the teams' style of play (Fernandez-Navarro, Fradua, Zubillaga, Ford, & Allistair, 2018; Hughes & Franks, 2005). Other studies focus on the time of goal scoring (Campos, Drezner, & Cortez, 2016; Leite, 2017; Njororai, 2014), showing that most goals are scored in the last 15–30 minutes of a game.

At the same time, several studies deal with a specific type of goal scoring: set plays (Bar-Eli, & Azar, 2009; Link, Kolbinger, Weber, & Stöckl, 2016; de Baranda, & Lopez-Riquelme, 2012). Set plays area vital part of the offensive as well as the defensive tactics of teams, as it appears to be one of the types of play that are most likely to result in goal scoring by the attacking team (Armatas, Giannakos, & Hatzimanouil, 2007).

Furthermore, as success in football means scoring at least one goal more than theopponent does, great emphasis is placed on parameters contributing to goal scoring, as well

Correspondence:

K. Papadimitriou
Democritus University of Thrace, Department of Physical Education and Sport Science, Campus, 69100 Komotini, Greece
E-mail: kpapadim@phyed.duth.gr

as creating goal-scoring opportunities (Mitrotasios, Gonzalez-Rodenas, Armatas, & Aranda, 2019; Wright, Atkins, Polman, Jones, & Sargeson, 2011). Diachronic analysis of goal-scoring ways, mainly in the case of top teams, may still result in new factors and game styles that could help coaches in different divisions improve specific offensive tactics that are better suited for their teams.

The results of the present study are expected to be of particular interest, due to the diametrically opposing views on football adopted in the two leagues, as Italian teams are expected to focus more on defensive tactics, whereas Spanish teams adopt a more attacking approach. According to the findings of a recent studyon goal-scoring opportunities, Italian teams played with shorter offensive sequences, while Spanish teams adopted long and combinative attacks (Mitrotasios et al., 2019).

The objective of the present study was to analyse the offensives that led to goal scoring by the top four teams of the Spanish and Italian Leagues in the 2017–2018 season. One of the objectives was to compare the match behaviours displayed by the teams of the two leagues in the case of goal scoring. Studying these two leagues is expected to be of particular interest due to their radically conflicting views on football. In Italy, the teams appear to focus more on defensive tactics; therefore, their style of play could be described as conservative. In contrast, Spanish teamsseem to focus mainly on attacking play, which results in a more spectacular display. Finally, the centralresearch hypothesis of the present study is that the styles of play resulting in goals in the two leagues differ from each other.

Method

Sample

The sample of the study consisted of 606 goals and 208 football matches played in Italy and Spain. More precisely, all goals scored by the top four teams of the Spanish and Italian Leagues in the 2017–2018 season were recorded and studied. Each of the teams participated in 38 games in its respective league. The reason that we opted to study these two leagues was the participation of some of the top European clubs such as Inter, Napoli, Roma, Juventus, Atletico Madrid, Barcelona, Valencia, and Real Madrid.

Data collection measuring instruments

The parameters studied were the following (Table 1):

1) League, 2) Time frame of goal scoring, 3) Type of attack, 4) Type of set play, 5) Starting zone of attack (Figure 1), 6) Actions leading to goal scoring, 7) Type of final action, 8) Zone of final pass, 9) Goal-scoring zone (Figure 2), 10) Number of passes.

Table 1. Categories of analysis and their parameters

Category	Parameters	Definition of Parameters
Time frame of goal scoring	00:01–15:00	
	15:01–30:00	
	30:01–45:00	
	first-half added time	
	45:01–60:00	
	60:01–75:00	
	75:01–90:00	
	second-half added time	
Type of attack	Organized attack	An attack of more than 3 passes resulting in goal scoring
	Counter-attack	An attack of 0–3 passes resulting in goal scoring
	Direct attack	An attack of 0–3 passes resulting in goal scoring, after recovering possession of the ball. As a direct attack was also considered the type of attacking play characterized by speed in the attacking third of the pitch
	Set play	Goal scoring from corner-kick, free-kick, penalty or any other situation where the ball is returned to open play following a stoppage (throw-in, goal-kick, off-side kick
Type of set play	Corner-kick	
	Free-kick	
	Penalty	
	Other	Throw-in, goal-kick, off-side kick
Starting zone of attack	Defending zone	
	Central zone and	
	Attacking zone	
Actions leading to goal scoring	Combination play with 3 or more players involved	
	Individual action,	
	Opponent turnover	i.e. wrong save

(continued on next page)

(continued from previous page)

Category	Parameters	Definition of Parameters
Type of final action	Header	
	Shot	i.e. tackle, back-heel kick
	Other	
Zone of final pass and goal-scoring zone	The penalty box1	All three areas outside the penalty box extend beyond the centreline of the pitch
	The central area outside the penalty box2	
	The right area outside the penalty box3	
	The left area outside the penalty box4	
Number of passes	0–3 passes	
	4–6 passes	
	More than 7 passes	

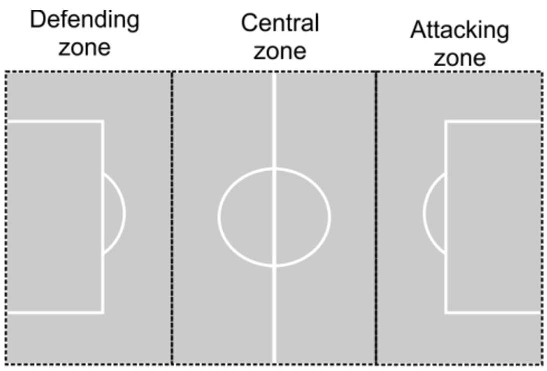


FIGURE 1. Field zone, starting zone of attack

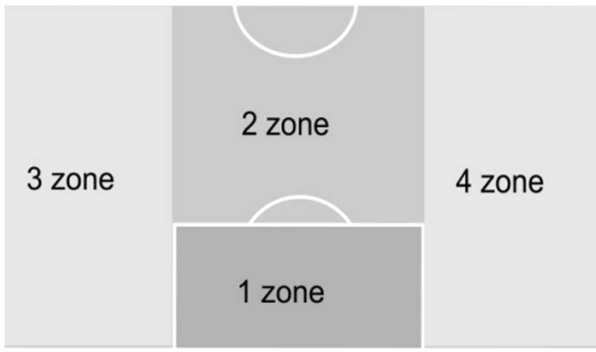


FIGURE 2. Field zone, Goal-scoring

Data analysis of every goal-scoring attack, along with the relevant parameters, was performed using the Sportscout video-analysis software; the recording of each attempt started when a player gained possession of the ball and ended when the ball passed over the goal line.

The observation protocol was drawn up with the assistance of a high-level football trainer who instructed the observer in recognizing 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 60 random goal-scoring attacks 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 60 selected goal-scoring attacks were observed. After one week, the same observation was repeated. In both cases, Cohen's Kappa value was exceptionally high (k=1.000).

Data analysis

The data were analysed using the SPSS statistical analysis software. The type of analysis used was the Crosstabs analysis and the criterion of the Chi-square test significance value $p<.05$. The purpose of the analysis was to determine whether the parameters contributing to goal scoring were different between the two leagues. Additionally, 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

According to the results (Table 2), as far as differences between the two leagues in goal-scoring attacks are concerned, they were significant only in the type of attack (Chi-square=14.540, $p<0.05$) and the attack-starting zone (Chi-square=9.321, $p<0.05$). More specifically, the Spanish teams studied appeared to utilize counter attacks more often than the Italian teams did (65% to 35%) while the latter tended to use direct attacks more frequently (58% to 42%). Concerning the starting zone of attack (Figure 4), it was found that the Spanish teams started their attacks from the defending zone (63% to 37%) and the central zone (54% to 46%) more frequently.

The Italian teams, in contrast, started their attacks mainly from the attacking zone (54% to 36%). However, due to the marginal value of p, it could be said that there was a small mismatch between the 75th and the 90th minutes, when more goals were scored in by the Spaniards than the Italians (59% and 41%, respectively). Furthermore, the number of goals scored by the Spanish teams between the 30th and the 45th minutes of the game was slightly higher (60% and 40% respectively). In contrast, the Italian teams tended to score more goals between the 45th and the 60th minutes (53% and 47% respectively).

Table2. Percentages of goal scoring parameters (Italian and Spanish league)

Category	Parameters	Italy	Spain
Time frame of goal scoring	00:01–15:00	52%	48%
	15:01–30:00	48%	52%
	30:01–45:00	40%	60%
	first-half added time	100%	0%
	45:01–60:00	53%	47%
	60:01–75:00	48%	52%
	75:01–90:00	41%	59%
	second-half added time	58%	42%
Type of attack ($p<0.05$)	Organized attack	44%	56%
	Counter-attack	35%	65%
	Direct attack	58%	42%
	Set play	53%	47%
Type of set play	Corner-kick	53%	47&
	Free-kick	64%	36%
	Penalty	45%	55%
	Other	42%	58%
Starting zone of attack ($p<.05$)	Defending zone	37%	63%
	Central zone and	46%	54%
	Attacking zone	54%	46%
Actions leading to goal scoring	Combination play with 3 or more players involved	46%	54%
	Individual action,	39%	61%
	Opponent turnover	50%	50%
Type of final action	Header	56%	44%
	Shot	45%	55%
	Other	55%	45%
Zone of final pass	The penalty box1	46%	54%
	The central area outside the penalty box2	44%	56%
	The right area outside the penalty box3	47%	53%
	The left area outside the penalty box4	56%	44%
Zone of goal scoring	The penalty box1	47%	53%
	The central area outside the penalty box2	48%	52%
	The right area outside the penalty box3	0%	0%
	The left area outside the penalty box4	100%	0%
Number of passes	0–3 passes	50%	50%
	4–6 passes	41%	59%
	More than 7 passes	41%	59%

Discussion

As mentioned, the aim of the present study was both to analyse the goal-scoring attacks by the top four Spanish and Italian teams andto draw a comparison between the respective football leagues.

According to the findings, it appears that all teams scored goals within the same time frames, with most goals scored mainly during the second half. There was a small, if insignificant, differentiation in the case of the Spanish teams, as they scored more often during the last fifteen minutes of the game, as well as during the timebetween the 30th and the 45th minutes. Similar goal-scoring behaviour was also observed in other studies in lower-level national leagues, such as in Greece, Brazil, and Ethiopia (Armatas, Giannakos, Papadopoulou, & Skoufas, 2009; Campos et al., 2016; Chekol, 2016) as well as in national-teams competitions, like the European Cup and the World Cup (Çobanoğlu, 2019; Leite, 2013; Tousios, Michailidis, Mandroukas, Mikikis, & Metaxas, 2018), leading to the conclusion that goal-scoring occurs more often during these specific periods of a football match. This outcome is further reinforced by the findings in the research by Leite (2017), who analysed an exceptionally large sample of matches and goals (8,200 goals and 3,100 matches), focusing his methodology solely on the moment of goal scoring. Moreover, most of the goals in the second half might have been a result of the teams of the present study taking advantage of the opponent's fatigue and psychological deterioration, which are usually evident among the players during the last minutes of a game (Leite, 2017).

As far as the types of goal-scoring attacks are concerned, the most popular ones with the teams of the sample were mainly organized attacks, and set plays. A similar conclusion was drawn in EURO 2012 (Leite, 2013), thereby confirming that the above-mentioned match behaviour has been adopted for at least several years, even by teams at different levels, which could be attributed to the nature of the sport itself. Specifically, extended ball possession and (the need for) the best possible organized attack might be a consequence of the size of the pitch and the presence of 20 players on it. The fact that the Spanish teams scored more goals than the Italian teams did through organized attacks or counter-attacks highlights their renowned game style that is dominated by extended passing game and powerful counter-attacks.

In the case of the Italian teams, their famously tough defence may be the reason for their being awarded more free kicks than the Spanish teams. As already mentioned, the set plays analysed in the current research resulted in 25–30% of the total number of goals, with similar results appearing in the international literature (Durlik & Bieniek, 2014; González-Rodenas, López-Bondia, Calabuig, Pérez-Turpin, & Aranda, 2017). The external validity of these results is significantly reinforced by the research of Cerrah, Özer and Bayram (2016), in which it was reported that during the last five seasons of the Turkish league (2006 to 2011), 102 goals were scored from set plays, accounting for 28% of the total number. Even though most studies focusing on set plays attempt to identify their most effective type (free kick or corner kick), the fact remains that they pose a severe threat to the defending team, provided they are taken by good set-play kickers.

As for the starting zones of the goal-scoring attacks, it appears that the teams from both leagues in the sample scored most of their goals when their attacks were initiated mainly in the attacking zone, followed by those starting in the central zone and last from the defensive zone. As a result, the attacking third of the pitch appears to be the starting zone of the most successful attacks performed by top teams (similar results were recorded in the study by Vergonis et al., 2019), which could be due to the pressure applied by these teams on their opponents in this specific area in order to gain possession of the ball.

Furthermore, from the results of the present study, it could be concluded that, compared to their Italian counterparts, the Spanish teams initiated their successful attacks from the defensive and the central zone more frequently, once again as a result of their passing-game style of play. The fact that the Italian teams started their successful attacks mainly from the attacking zone may be attributed to the adoption of a defensive tactical profile while on defence as well as when applying pressure on their opponents in the attacking third of the pitch.

Concerning the attacks made, there was no significant difference between the teams of both leagues. However, their primary attacking tactic was combination play with three or more players involved. The higher percentage of goal-scoring resulting from combination play is partially explained by the fact that most of the times when top teams are required to deal with tight defensive formations, they resort to this style of play in order to break them and create spaces. Correspondingly, it is understandable that many goals are scored from individual actions, as some of the players in those teams are among the best (or even the best) worldwide, with the Spanish teams scoring more goals from individual actions, a feature for which their players are particularly known. An identical parameter among the teams in both leagues was the ability to capitalize on the opponent turnovers by turning them into goals, mainly thanks to the ability possessed by top teams to take advantage of even the minor errors of their opponent.

Moreover, the numbers of successful final attempts by the teams in both leagues were also identical. Shots were the most frequent type of final attempt, which has also been confirmed by other studies, providing indisputable evidence that shot is the technical action resulting in the higher number of goals. Concerning the fact that Spanish teams tend to score goals from shots, it may be due to their implementation of fast combination game in their attacks, which requires the ball to be on the ground for the most significant part of an attack resulting in more shots than headers. Accordingly, the higher percentage of goal-scoring headers by the Italian teams may be attributed to their relatively higher number of crosses or even set plays (especially free kicks and corner kicks).

Another variable related to the build-up of successful attacks is the zone of the final pass resulting in goal scoring. According to the results of the present study, most of the final passes of all the teams studied were initiated in the central areas of the pitch and, more specifically, the central area outside the penalty box. This tactic seems to be employed not only by the top teams in their national leagues but also in football competitions like the World Cup of 2018, in which, according to Çobanoğlu (2019), 61% of the assists were made from the central areas of the field.

Additionally, we could conclude from the above that it is necessary to examine the different types of goals-scoring, as they could ultimately help teams, and especially their attacking players, score more goals than their opponents. For this reason, the attackers must be at the right place at the right time, which is why the goal-scoring zone appears to be a significant parameter, as it represents the most probable areas of goal-scoring. Based on the results, in both leagues, more than 80% of the goals came from within the penalty area, a fact that was confirmed in all studies that examined this specific variable (Njororai, 2013; Chekol, 2016; Wright et al., 2011; González-Ródenas et al., 2019).

As for the number of passes leading to goals, it is mentioned in the international literature that the successful attacks of high-level teams (English Premier League and 2010 World Cup) usually consist of up to three or in some cases four passes (González-Rodenas, López-Bondia, Calabuig, & Aranda, 2015; Wright et al., 2011). More specifically, as indicated by the results of these studies, most of the goal-scoring opportunities were created, while in possession of the ball, after up to three or, in several cases, four passes. The present study resulted in similar findings with slight variations, once again reflecting the profile and the coaching philosophy of both leagues. With reference to their results, the Spanish teams appear to make up to six or more passes during a substantial number of their successful attacks.

At this point, we would like to call attention to the possibility that some or even all of the studied parameters leading to goal-scoring may also occur in unsuccessful attacks. It is almost certain that goal scoring is affected by other factors, such as a mistake in the final attempt, a save by the goalkeeper, a good shot gone wide, or a foul committed by the opponent. However, the sample dynamics (four of the best teams in top leagues), as well as the substantial number (606) of goal-scoring attacks that were observed, justifies the suggestion that the resulting parameters be used in creating better goal-scoring situations.

Although the top teams studied from the Spanish and Italian league adopted a similar goal-scoring playing profile, certain dissimilar aspects confirm their different playing styles. The Spanish League, on the one hand, was characterized by passing and the fact that the attacks tend to initiate even behind the centre of the field; on the other hand, one of the features of the Italian teams was the defensive style of play and the overall tendency to start the attacks mainly from the attacking zone and score goals from set plays. Although the above aspects are derived from different coaching philosophies, they could be incorporated in a common coaching principle that could be adopted by rising teams at the same or different levels in order to improve their match performance.

Acknowledgements
There are no acknowledgements.

Conflict of Interest
The authors declare the absence of conflict of interest.

Received: 20 April 2020 | **Accepted:** 07 June 2020 | **Published:** 01 February 2021

References

Armatas, V., Giannakos, A., Papadopoulou, S., & Skoufas, D. (2009). Evaluation of goals scoring in top ranking soccer matches Greek Super league 2006-07. *Serbian Journal of Sport Sciences, 3*(1), 39-43.

Armatas, V., Giannakos A., & Hatzimanouil, D. (2007). Record and Evaluation of Set-Plays in European Football Championship in Portugal 2004. *Inquiries in Sport & Physical Education*, *5*(2), 302-307.

Bar-Eli, M., & Azar, H. O. (2009). Penalty kicks in soccer: an empirical analysis of shooting strategies and goalkeepers" preferences. *Soccer & Society*, *10*(2), 183–191. doi:10.1080/14660970802601654

Campos, N., Drezner, R., & Cortez, J. (2016). Análise da ocorrência temporal dos gols no Campeonato Brasileiro 2011. *Revista Brasileira de Ciências do Esporte*, *38*(1), 58-63. doi: 10.1016/j.rbce.2015.11.011

Carling, C., Williams, A., & Reilly, T. (2005). *The handbook of soccer match analysis.* Routledge.

Cerrah, A. O., Özer, B., & Bayram, I. (2016). Quantitative Analysis of Goals Scored from Set Pieces: Turkey Super League Application. *Türkiye Klinikleri Journal of Sports Sciences, 8*(2), 37-45. doi:10.5336/sportsci.2016-50745

Chekol, B. (2016). Analysis of goal scoring prototype in the 2014/15 final qualifying competition to premiere entrance in Ethiopia. *International Journal of Physical Education, Sports and Health, 3*(3), 17-22.

Çobanoğlu, H. O. (2019). Analysis of Goal Scored on Russia World Cup 2018. *Journal of Education and Training Studies, 7*(2), 184-191. doi:10.11114/jets.v7i2.3998

Durlik, K., & Bieniek, P. (2014). Analysis of goals and assists diversity in English Premier League. *Journal of Health Sciences, 4*(05), 47-56.

Fernandez-Navarro, J., Fradua, L., Zubillaga, A., Ford, P. R., & Allistair P.M. (2018). Influence of contextual variables on styles of play in soccer. *International Journal of Performance Analysis in Sport, 18*(3), 423-436. doi:10.1080/24748668.2018.1479925

González-Rodenas, J., López-Bondia, I., Calabuig, F., & Aranda, R. (2015). Tactical Indicators associated with the creation of goal scoring opportunities in professional soccer. *Cultura Ciencia y Deporte, 10*(30), 215-225.

González-Rodenas, J., López-Bondia, I., Calabuig, F., Pérez-Turpin, J.A., & Aranda, R. (2017). Creation of goal scoring opportunities by means of different types of offensive actions in US Major League Soccer. *Human Movement*, *18*(5), 98-108. doi:10.5114/hm.2017.73616

Hughes, M. & Franks, I. (2005). Analysis of passing sequences, shots and goals in soccer. *Journal of Sports Sciences, 23*(5), 509–514. doi: 10.1080/02640410410001716779

Leite, W. S. S. (2013). Euro 2012: Analysis and Evaluation of Goals Scored. *International Journal of Sports Science, 3*(4), 102-106. doi: 10.5923/j.sports.20130304.02

Leite, W. S. S. (2017). Temporal analysis of goals scored in European football leagues soccer. *International Journal of Yogic, Human Movement and Sports Sciences, 2*(1), 33-36.

Link, D., Kolbinger, O., Weber, H., & Stöckl, M. (2016). A topography of free kicks in soccer. *Journal of Sports Sciences*, *34*(24), 2312–2320. doi: 10.1080/02640414.2016.1232487

Mitrotasios, M., Gonzalez-Rodenas, J., Armatas, V. & Aranda, R. (2019). The creation of goal scoring opportunities in professional soccer. Tactical differences between Spanish La Liga, English Premier League, German Bundesliga and Italian Serie A. *International Journal of Performance Analysis in Sport, 19*(3), 452-465. doi: 10.1080/24748668.2019.1618568

Njororai, W.W. S. (2013). Analysis of goals scored in the 2010 world cup soccer tournament held in South Africa. *Journal of Physical Education and Sport*, *13*(1), 6-13. doi: 10.7752/jpes.2013.01002

Njororai, W. S. S. (2014). Timing of Goals Scored in Selected European and South American Soccer Leagues, FIFA and UEFA Tournaments and the Critical Phases of a Match. *International Journal of Sports Science, 4*(6A), 56-64. doi: 10.5923/s.sports.201401.08

Palomino, F. A., Rigotti, L., & Rustichini, A. (1998). Skill, Strategy and Passion: An Empirical Analysis of Soccer. *Tilburg University.* Retrieved April, 2019 from http://research.tilburguniversity.edu/en/publications/skill-strategy-and-passion-an-empirical-analysis-of-soccer

Sainz de Baranda, P., & Lopez-Riquelme, D. (2012). Analysis of corner kicks in relation to match status in the 2006 World Cup. *European Journal of Sport Science*, *12*(2), 121-129. doi: 10.1080/17461391.2010.551418

Stolen, T., Chamari, K., Castagna, C., & Wisloff, U. (2005). Physiology of soccer. An Update. *Sports Medicine, 35*(6), 501-536. doi: 10.2165/00007256-200535060-00004

Tousios, T., Michailidis, Y., Mandroukas, A., Mikikis, D., & Metaxas, T. (2018). Differences in goal scoring and minutes of scoring between two European Championships, one among 16 teams (Euro 2012) and the other among 24 teams (Euro 2016). *Series Physical Education and Sport*, *16*(2), 365-373. doi: 10.22190/FUPES180820033T

Vergonis, A., Michailidis, Y., Mikikis, D., Semaltianou, E., Mavrommatis, G., Christoulas, K., & Metaxas, T. (2019). Technical and tactical analysis of goal scoring patterns in the 2018 FIFA World Cup in Russia. *Physical Education and Sport*, *17*(2), 181-193. doi: 10.22190/FUPES190612019V

Wright, C., Atkins, S., Polman, R., Jones, B., &Sargeson, L. (2011). Factors Associated with Goals and Goal Scoring Opportunities in Professional Soccer. *International Journal of Performance Analysis in Sport, 11*(3), 438-449. doi: 10.1080/24748668.2011.11868563

DOI 10.26773/smj.210204

ORIGINAL SCIENTIFIC PAPER

Monitoring the Internal and External Loads of Young Team Handball Players during Competition

Dora Maric[1,2], Barbara Gilic[1,3], Nikola Foretic[1]

[1]University of Split, Faculty of Kinesiology, Split, Croatia, [2]University of Palermo, PhD Program in Health Promotion and Cognitive Sciences, Palermo, Croatia, [3]University of Zagreb, Faculty of Kinesiology, Zagreb, Croatia

Abstract

This study aimed to examine the internal- and external-training-load (ITL and ETL, respectively) during a match of young handball players. Field testing included heart-rate monitoring (memory belt, Suunto) as a marker of ITL and accelerometry (motion-biosensor, Actical Respironcis, Philips) as a marker of ETL. Time motion analysis data were obtained by recording the player's game activities and later analysed with the Matlab software package. T-test and Pearson-product-moment correlation coefficient were used to examine the differences and the relationship between variables collected in the study. The t-test analysis did not show significant differences between the total distance covered (2216.42–2135.42 m), steps conducted (1829.25–1829.83 steps), steps per minute (91.46–91.49 steps/min), energy expenditure (92.24–90.87 METS), time spent in higher intensity zones calculated by motion biosensor (13.08–12.75 minutes), training-load calculated by Edwards TRIMP method (91.54–88.56 scores) in the first and in the second half of the match. Physical activity variables show no significant correlations with the data assessed by heart rate monitors. Similar results in monitored training-load variables in the first and second halves are connected with the game intensity, which was consistent throughout the match. The lack of correlations between ITL and ETL variables indicates that accelerometry is not suitable for the assessment of metabolic training load in intermittent activities, such as handball. ITL measures used in this study are more suitable for controlling load during training and competition, while the ETL parameters used are more appropriate for better understanding players activity in periods in which the players do not train; other activities can influence players fatigue and training and competition performance.

Keywords: *heart rate, accelerometry, Actical, match, energy expenditure, distance covered*

Introduction

The necessity of the improvement and individualization of training programmes has led to the development of technologies used for monitoring (quantifying) training and match activities (Halson, 2014; Cardinale & Varley, 2017). Successful monitoring of training and match load provides a better image of individual training tolerances, which is affected by numerous factors, such as the player's age, previous experience, fitness level, nutrition, and recovery practices (Coutts, Wallace, & Slattery, 2004; Havolli, Bahtiri, Begu, Ibrani, & Makolli, 2018). Accordingly, the data obtained provide a firm basis for optimal training periodization and consequentially maximizing athletic performance, reducing injury risk, and avoiding overreaching and overtraining syndromes (Soligard et al., 2016; Cardinale & Varley 2017).

In general, the principle of training can be simply displayed as a dose-response relationship between the physiological stress combined with the training load ("dose") and the training adaptations ("response") (Borresen & Lambert, 2009). That being said, it is clear that internal and exter-

Correspondence:

D. Maric
University of Split, Faculty of Kinesiology, Nikole Tesle 6, 21000, Split, Croatia
E-mail: do.maric@gmail.com

nal training loads employ different pathways and thus need to be monitored and analysed complementarily (Lambert & Borresen, 2010). More precisely, the internal training load (ITL) represents the psycho-physiological response by the athlete that primarily takes the form of biochemical stress, and it is usually assessed by heart rate (HR), haematological measures, and perceptual rating of intensity (Williford, Olson, Gauger, Duey, & Blessing, 1998; Scott, et al. 2013). External training load (ETL) represents the activities performed by athletes (i.e., the dose performed) and is measured independently of their internal characteristics, quantified by measuring distance covered speed, acceleration, duration, metabolic power, body load, and sport-specific movements (Williford et al. 1998; Scott, Black, Quinn, & Coutts, 2013).

Handball is an intermittent high-intensity Olympic team sport characterized by specific tactical and physiological demands (Granados, Izquierdo, Ibanez, Ruesta, & Gorostiaga, 2008; Souhail, Castagna, Mohamed, Younes, & Chamari, 2010). Match activity is characterized by a significant number of rapid changes of direction, sideward movements, sprints, jumps, throws, and body-contacts (Buchheit et al., 2009). Therefore, understanding the demands of the game is essential for the design of handball-specific training drills in both professional and developing players (Karcher & Buchheit, 2014; Muratovic & Georgiev, 2012). However, regardless of its popularity (mainly in Europe) research is limited to some extent; more particularly, there is a lack of research examining the specific demands and impact it has on youth players and how they differ from seniors (Foretic, Uljevic, Cardinale, & Spasić, 2018).

That being said, this study aimed to examine the internal and external training load (TL) during the match of young handball players and compare results obtained with systems for assessing ITL (HR) with results obtained with systems for assessing ETL.

Methods

Participants

Twelve young male team handball players, (age: 13.33± 0.57, body height: 168.25 ±12.15 cm, body weight: 57.09±13.31 kg, body fat: 9.33% ±1.19%), regularly training for at least three years, took part in this study. Subjects were all members of the handball club from Split, Croatia, and regular participants in the finals of the Croatian national championship. Because all participants belonged to the same team, they had the same handball training programmes during the three years before the study took place. Participants were asked to attend one laboratory session for the determination of maximal oxygen uptake and two handball games.

Laboratory and field testing

The study was conducted during the competitive season. The participants and their parents were fully informed about testing procedures before participating in the study; informed consent was signed by the parents. The ethics committee of the Faculty of Kinesiology of the University of Split confirmed and approved the study.

Laboratory testing included basic anthropometric measurements and spiroergometry testing during an incremental running protocol on a treadmill. Seven spiroergometry parameters were determined during the treadmill test, and HRmax was used to determine intensity zones during the games and to calculate total training load (TL).

Time-motion analysis data were obtained through the recording of the players' game activities. One video camera (Sony, HDR-XR520V, Tokyo, Japan) was positioned on a tripod 20 m above the team handball court and parallel to the edge of the court (15 m from the touchline), so it could cover the entire field during recording. Match recordings were later replayed and analysed with a bespoke software package developed with Matlab (Mathworks, Natick, USA) to extract time-motion data. Players' movements (distance covered) were measured on the horizontal plane. A specific algorithm was developed in Matlab so that the number of pixels that centre of mass travelled on the screen in any direction represented the true player's distance travelled on the court on the horizontal plane. Velocity was calculated using distance and time data (v=s/t, where v=speed, s=distance, t=time). Manual and semi-automated tracking was used to determine the path for each player. Time was calculated by counting the number of frames between the starting and ending positions of a player's movement (one frame=1/25 of second). Heart rate data were recorded with chest straps (Suunto T6, Vantaa, Finland), which were worn by the players 30 min before the start of the experimental game and removed 30 min after the end. Heart rate-based intensity zones were determined individually by using the results of the spiroergometry test, as a reference, as follows: 50–60 % HRmax (Z1), 60–70 % HRmax (Z2), 70–80 % HRmax (Z3), 80–90 % HRmax (Z4) and 90–100 % HRmax (Z5). The Edwards' Heart Rate–Based Method was used to determine the TL of the game measured. Blood samples were collected at two predetermined time points throughout the matches from the fingertips. The blood samples were immediately placed on strips for analysis in a validated portable lactate analyser (Accutrend; Roche, Mannheim, Germany). The analysis was conducted using six identical lactate analysers. Blood sampling and lactate analysis were conducted by six trained sports scientists. The capillary blood samples were collected after the first half and after the second half of the matches.

The Actical accelerometer was used to gather the following activity data: number of steps, total energy expenditure (TotEE) and time spent in activity zones; it is a small, water-resistant accelerometer (28×27×10 mm, 17 g). It has a multi-directional sensor and is capable of measuring movement in three planes. For the present study, the monitors were initialized to save data in 60-second intervals (epochs) to detect the activities of players. Players wore the accelerometers on the right ankle secured and supported with an elastic belt and kinesio-tape.

Design

The training games used for analysis were organized against two teams that play in the same league as the participants of the study. Before each game, the participants performed a typical warm-up that lasted 15 minutes (3 minutes of dynamic warm-up, 5 minutes passing drills, and 7 minutes situational drills with shots on goal). Each half of the game lasted 20 minutes without stopping time and with a break of five minutes between the two halves as per national league rules for this age group. All participants were playing without rolling substitutions, so each player had to play the whole game of 40 min. The defensive system adopted in both games was a 3:3 formation. Game rules were modified so that the players could not be excluded (power play) from play. This enabled continuity of the situational load during the game.

Statistical analyses

Statistica ver. 12 software was used in the data analysis. The level of significance was set at the alpha level of 0.05. Descriptive data for all the variables are shown as mean and SD. The normality of all variables was tested using the Kolmogorov-Smirnov test procedure. Student's t-test was used to examine the differences between the first and second halves. The Pearson product-moment correlation coefficient was used to assess the relationship between variables collected in the study. Data are presented as mean and SD. Alpha was set at $p<0.05$.

Results

The data on intensity zones showed that the players spent a large percentage of the total playing time in high-intensity heart rate zones (Table 1). Blood lactate measurements conducted at the end of each half of the game reached values below 10 mmol/L, and a significant reduction in blood lactate was evident between the first and the second half of the game. The time-motion analysis did not show significant differences in the total distance covered by players in the first (2220.50±162.85 m) and in the second (2131.42±239.80 m) half of the match. Average speed in the first half (6.17±1.79 km/h) was almost the same as in the second half (6.18±1.96 km/h). There was no difference in the time spent in different time zones between first and second halves, for Edward TRIMP and Actical measurement, respectively. According to the Actical measurement, the number of steps and total energy expenditure was almost the same in the first and the second halves of the match.

Tables 2 and 3 present correlations between variables of internal and variables of external load during the first and second halves of the match. Only one statistically significant correlation was observed: between lactate concentration and total energy expenditure.

Table 1. Differences between First and Second Half of the Match Calculated With T-Test

Variables	1st Half-Time M±SD	2nd Half-Time M±SD
Steps	1829.25±142.61	1829.83±153.14
TotEE (METs)	92.24±5.20	90.87±4.45
Time/vigorous (min)	13.08±4.58	12.75±2.99
Time/moderate (min)	6.92±4.58	7.25±2.99
Distance (m)	2216.42±169.70	2135.42±236.71
Lactate (mmol/L)	6.07±2.13*	4.31±1.19*
Z5 (%)	57.44±27.42	48.05±31.20
Z4 (%)	34.10±23.10	40.51±25.78
Speed (m/s)	6.76±1.09	6.77±1.39

Legend: Steps-number of steps; TotEE-total energy expenditure; Time/vigorous-time spent in vigorous activity zone; Time/moderate- time spent in moderate activity zone; Distance-distance covered; Lactate-blood lactate concentration level: Z5- 90-100 % of maximal HR zone; Z4- 80-90 % of maximal HR zone; Speed- average speed of movement

Table 2. Correlations between Variables of Internal and External Load during - First Half of the Match

Variables	D	AS	Steps	TotEE	Time(mod)	Time(vig)
L	0.50	0.40	-0.05	0.59*	-0.53	0.53
HR	0.23	0.29	-0.25	-0.10	0.11	-0.11
Z5	0.22	0.31	-0.08	0.02	0.10	-0.10
Z4	-0.19	-0.23	0.06	0.07	-0.15	0.15
Z3	-0.17	-0.31	0.03	-0.27	0.20	-0.20

Legend: D-distance covered; L-blood lactate concentration level; Z5-90-100 % of maximal HR zone; Z4-80-90 % of maximal HR zone; Z3-70-80 % of maximal HR zone; AS-average speed of movement

Table 3. Correlations between Variables of Internal and External Load during - Second Half of the Match

Variables	D	AS	Steps	TotEE	Time (mod)	Time (vig)
L	0.54	0.49	0.11	0.37	-0.32	0.32
HR	0.35	0.27	0.15	0.15	-0.08	0.08
Z5	-0.05	0.15	0.13	0.16	-0.12	0.12
Z4	0.17	-0.11	-0.10	-0.10	0.03	-0.03
Z3	-0.43	-0.26	-0.04	-0.18	0.27	-0.27

Discussion

This study has several interesting results: 1) although the second half of the match had decreases (or stagnation) in all measured parameters, the only significant difference was noticed in blood lactate concentration, 2) in the first half of the match, the only significant correlation was observed between lactate concentration and total energy expenditure, 3) there are no correlations between ITL and ETL variables during both halves of the match.

From all parameters of training load used in the study, it is evident that the second half of the match was less demanding than the first one. This change was evident on a statistically significant level only for L concentration. Many authors agree that blood lactate concentration is very sensitive to changes in exercise intensity and duration (Beneke, 2003; Faude, Kindermann, & Meyer, 2009; Beneke, Leithäuser, & Ochentel, 2011). In this research, we observed the same trend. The question is why other load-monitoring systems did not recognize a shift of match intensity. Should we not expect that a decrease of L concentration will be associated with a decrease of HR and energy expenditure (Coutts, Reaburn, & Abt, 2003)? We can only speculate about the reasons, but this underscores the complexity of training load monitoring, specifically in pre-adolescents (Halson, 2014; Murray, 2017).

In the first half of the match, a significant correlation was detected only between lactate concentration and total energy expenditure, which is easily explainable. Lactate levels depend primarily on the intensity of the exercise; accordingly, moderate-to-heavy intensity activities can cause lactate levels to rise rapidly and, if the workload continues, the lactate level may stabilize, decline, or continue to rise, depending on training status and genetic characteristics of the individual (Plowman & Smith, 2013). Furthermore, with regard to total energy expenditure, it is well known that it increases in direct proportion to the increase in exercise intensity (Plowman & Smith, 2013). Thus, given that the tested sample consisted of pre-adolescent players whose energy capacities did not allow them to maintain the same intensity through the second half of the game, we may assume that a drop in intensity has led to a decrease in blood lactate levels; however, this was not the case with the total energy expenditure since the gameplay continued.

Regarding the lack of correlations between ITL and ETL variables during both halves of the match, it is essential to note the fact that ITL and ETL use different pathways; thus, they are measured complementarily. As previously mentioned, EL refers to any external stimulus applied to the athlete, resulting in psychological and physiological responses, which are referred to as "internal load" (Borresen & Lambert, 2009; Halson, 2014). Accordingly, in team sports, the TL is primarily derived from team practices, and EL parameters are collectively defined. Therefore, internal responses to the external load could potentially vary (Svilar & Jukic, 2018). For example, in the present study, the number of steps did not change a lot between the two halves of the match, but the L level did (Figure 1). The only logical conclusion that can be established from given results is that number of steps cannot be a marker of intensity like L is.

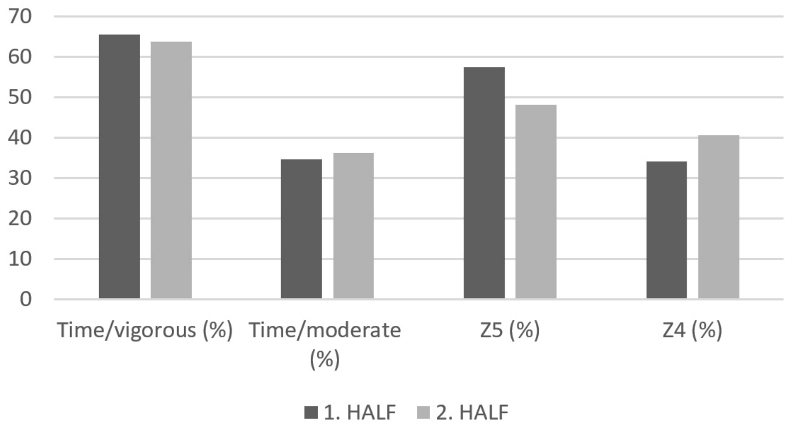


FIGURE 1. Comparison of Accelerometry and Edward's TRIMP Zones in 1st and 2nd halves of the match

In contrast, according to the accelerometry data, we can say that pre-adolescent handball players are very active since they spend the majority of their time in the zone of vigorous activity. Thus, the lack of correlations between ITL and ETL in pre-adolescent handball players in competitive conditions is not atypical (Borresen & Lambert, 2009; Akubat, Patel, Barrett, & Abt, 2012). On the contrary, it is simply a confirmation of current attitudes in this area of research that ITL and ETL should be used in different contexts of measurement (Halson, 2014).

Monitoring the training load of young athletes is very important for coaches when designing appropriate training programmes. Data from the competition are of even greater importance, especially in sports like handball, which induce

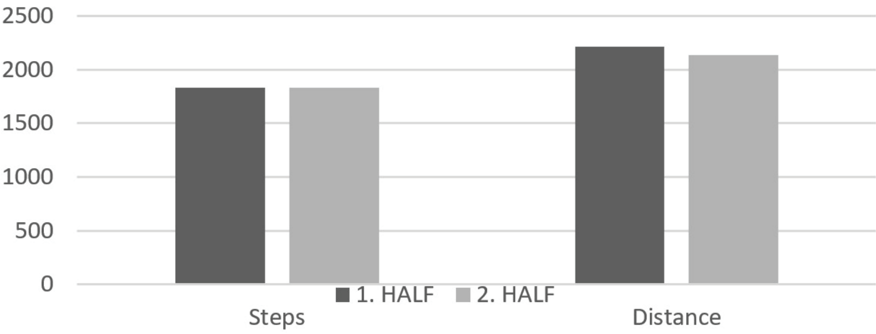


FIGURE 2. Comparison of Step Number and Distance Covered in 1st and 2nd halves of the match

strong physical and psychological responses. From this study, it is evident that in handball, different systems of monitoring produce different data, and these should not be considered in the same context. These differences are mostly seen in lack of correlations between ITL and ETL parameters (Figure 2).

It should be noted that accelerometers have many advantages, but they also have some limitations. The most problematic limitation is the inability of measuring the intensity of physical activity, which was observed in our study. One example is the cumulative number of steps (or volume of activity) taken during a bout of activity. This data offers no information regarding the intensity at which those steps were accumulated. Accordingly, in pre-adolescent handball players, during competition, blood lactate concentration and HR should be used as a measure of intensity while kinematic, and accelerometry data should be used as a measure of activity volume. Results of the study may be helpful for handball coaches who work with pre-adolescent handball players. It can help them to choose the correct method of training and competition load measurement. All cited authors think that ITL measures used in this study are more suitable for controlling load during training and competition. At the same time, ETL measures can help coaches better understand players' activity when the latter do not train (i.e., when they are at home or school) and other activities that can influence players fatigue and training and competition performance.

Acknowledgements
There are no acknowledgements.

Conflict of Interest
The authors declare the absence of conflict of interest.

Received: 15 March 2020 | **Accepted:** 10 May 2020 | **Published:** 01 February 2021

References

Akubat, I., Patel, E., Barrett, S., & Abt, G. (2012). Methods of monitoring the training and match load and their relationship to changes in fitness in professional youth soccer players. *Journal of sports sciences*, *30*(14), 1473–1480. https://doi.org/10.1080/02640414.2012.712711

Beneke, R. (2003). Methodological aspects of maximal lactate steady state—implications for performance testing. *European Journal of Applied Physiology, 89*(1), 95-99.

Beneke, R., Leithäuser, R. M., & Ochentel, O. (2011). Blood lactate diagnostics in exercise testing and training. *International journal of sports physiology and performance*, *6*(1), 8–24. https://doi.org/10.1123/ijspp.6.1.8

Borresen, J. & Lambert, M. I. (2009). The quantification of training load, the training response and the effect on performance. *Sports medicine, 39*(9), 779-795.

Buchheit, M., Laursen, P. B., Kuhnle, J., Ruch, D., Renaud, C., & Ahmaidi, S. (2009). Game-based training in young elite handball players. *International journal of sports medicine*, *30*(4), 251–258. https://doi.org/10.1055/s-0028-1105943.

Cardinale, M., & Varley, M. C. (2017). Wearable training-monitoring technology: applications, challenges, and opportunities. *International journal of sports physiology and performance, 12*(s2), S2-55-S52-62.

Coutts, A., Reaburn, P., & Abt, G. (2003). Heart rate, blood lactate concentration and estimated energy expenditure in a semi-professional rugby league team during a match: a case study. *Journal of sports sciences*, *21*(2), 97–103. https://doi.org/10.1080/0264041031000070831

Coutts, A., Wallace, L., & Slattery, K. (2004). Monitoring training load. *Sports Coach, 27*(1), 12-14.

Faude, O., Kindermann, W., & Meyer, T. (2009). Lactate threshold concepts: how valid are they?. *Sports medicine (Auckland, N.Z.)*, *39*(6), 469–490. https://doi.org/10.2165/00007256-200939060-00003

Foretic, N., Uljevic, O., Cardinale, M., & Spasić, M. (2018). Match demands of elite preadolescent team handball players: A preliminary study. *Medicina dello Sport, 71*(2), 190-202. doi: 10.23736/S0025-7826.18.03107-1.

Granados, C., Izquierdo, M., Ibanez, J, Ruesta, M., & Gorostiaga, E. M. (2008). Effects of an entire season on physical fitness in elite female handball players. *Medicine & Science in Sports & Exercise, 40*(2), 351-361.

Halson, S. L. (2014). Monitoring training load to understand fatigue in athletes. *Sports medicine, 44*(2), 139-147.

Havolli, J., Bahtiri, A., Begu, B., Ibrani, A., & Makolli, S. (2018). Monitoring of Some Strength Parameters in Handball. *Sport Mont, 16*(1), 37-39.

Karcher, C., & Buchheit, M. (2014). On-court demands of elite handball, with special reference to playing positions. *Sports medicine, 44*(6), 797-814.

Lambert, M. I., & Borresen, J. (2010). Measuring training load in sports. *International journal of sports physiology and performance, 5*(3), 406-411.

Muratovic, A., & Georgiev, G. (2012). Basic motor abilities and situational motor efficiency with young handball players from montenegro - quantitative approach. *Sport Mont, X*(34-35-36), 493-498.

Murray, A. (2017). Managing the training load in adolescent athletes. *International Journal of Sports Physiology and Performance, 12*(s2), S2-42-S42-49.

Scott, T. J., Black, C. R., Quinn, J., & Coutts, A. J. (2013). Validity and reliability of the session-RPE method for quantifying training in Australian football: a comparison of the CR10 and CR100 scales. *Journal of strength and conditioning research*, *27*(1), 270–276. https://doi.org/10.1519/JSC.0b013e3182541d2e

Soligard, T., Schwellnus, M., Alonso, J. M., Bahr, R., Clarsen, B., Dijkstra, H. P., … Engebretsen, L. (2016). How much is too much? (Part 1) International Olympic Committee consensus statement on load in sport and risk of injury. *British journal of sports medicine*, *50*(17), 1030–1041. https://doi.org/10.1136/bjsports-2016-096581

Souhail, H., Castagna, C., Mohamed, H. Y., Younes, H., & Chamari, K. L. (2010). Direct validity of the yo-yo intermittent recovery test in young team handball players. *The Journal of Strength & Conditioning Research, 24*(2), 465-470.

Svilar, L. & Jukic, I. (2018). Load monitoring system in top-level basketball team: Relationship between external and internal training load. *Kinesiology, 50*(1), 25-33. doi: 10.26582/k.50.1.4.

Williford, H. N., Olson, M. S., Gauger, S., Duey, W. J., & Blessing, D. L. (1998). Cardiovascular and metabolic costs of forward, backward, and lateral motion. *Medicine and science in sports and exercise*, *30*(9), 1419–1423. https://doi.org/10.1097/00005768-199809000-00011

DOI 10.26773/smj.210209

SportMont

ORIGINAL SCIENTIFIC PAPER

The Effect of Physical Exercise according to a Programme for the Development of Flexibility in the Motor Abilities of Young Football Players

Sami Sermaxhaj[1], Fitim Arifi[1,2], Jeton Havolli[1], Fadil Luta[1] and Imran Isufi[3]

[1]College Universi, Physical Culture Sport and Recreation, Prishtina, Kosovo, [2]University of Tetova, Physical Education and Sport, Tetova, North Macedonia, [3]Institute of Sports Anthropology, Prishtina, Kosovo

Abstract

This research aims to establish the effect of flexibility exercise on the motor abilities of young football players. The total number of participants was 68 young football players (beginners, pioneers, and cadets) from the Ramiz Sadiku Football Club in Prishtina, Kosovo. The participants were divided into control and experimental groups. The research implemented seven variables for estimating motor abilities. The effect of physical exercise according to the programme of flexibility on the motor abilities of young football players was investigated using uni-variant analysis. The course of preparatory and competition period training programme was conducted three times per week, for both groups. Only the manner of execution of the experimental programme was different (17 exercises of static stretching) for the development of flexibility, which was conducted only with the experimental group within the frame of increased duration by the end of the training. The results acquired show that programme conducted for the development of flexibility (exercised of static stretching) has a statistically significant effect only on flexibility variable "sit-and-reach test" with the experimental group of cadets, and with no statistically essential influence on the motor abilities of beginners, pioneers, and cadets. Therefore, it can be confirmed that static exercises have an essential effect on the improvement of flexibility of participants older than 15 years old, but without positive or negative effects on other variables of the motor abilities of young players.

Keywords: *flexibility, recovery, motor abilities, soccer players*

Introduction

Football is a collective sport: poly-structural, acyclic and highly complex. Success in a football game depends on many factors, one of the most important of which is motor skills. Such skills or the conditional preparation of them is the basis for the execution of technical and tactical movements during the football game, during which a player carries out 1400–1600 activity (runs, dribbles, jumps, kicks, headers, tackles, etc.) changes; 700–800 of these changes consist in changes of direction and/or speed, and only 11% of the total travelled distance is run at high speed (Williams et al., 2005).

The execution of numerous movements during a football game (speed runs, fast runs with changes of direction (acceleration and braking), jumping, execution of technical movements with the ball, depends on the flexibility of the locomotor system of the football player among others.

Therefore, only football players with optimal development of body flexibility can maximally exploit their motor skill potential, especially those skills characterized by explosive movements (sprint, strike, jumping) and agility. According to many authors, flexibility is defined as the skill to execute movements with higher amplitude (Walker, 2006; Gardasevic & Bjelica, 2013).

The importance of flexibility is seen in the results of a study between two groups of young football players: flexible and

Correspondence:

S. Sermaxhaj
College Universi, Physical Culture Sport and Recreation, Bardhosh 10000, Prishtina, Kosovo
E-mail: sermaxhajsami@live.com

those less flexible. The research has confirmed that more flexible football players have shown better results in speed tests, jumping and agility, which indicates that flexibility should be developed- trained from a young age (Garcia-Pinillos, Ruiz-Ariza, Moreno del Castillo, & Latorre-Roman, 2015).

However, the specific application of flexibility exercises is one of the most discussed topics in sport and medicine. There are different thoughts about flexibility exercises: when and to what extent the use of flexibility exercises is favourable or not.

Many studies have proved that static stretching exercises have a negative effect if they are applied directly before testing the jumping force, speed, and agility (Kay & Blazevich, 2011; Behm & Kibele, 2007).

Other studies have shown that the application of combined dynamic and static stretching during the warm-up phase increases the movement amplitude and has no adverse effect on motor skills (Behm, Chaouachi, Lau, & Wong, 2011; Kyranoudis et al., 2018).

Different concepts regarding this depend on the application methods, and when and to what extent the stretching forms should be applied for the development of flexibility (Brandey, Ajit, Richard, & Jennifer, 2012).

Easy runs and static stretching characterize the ending part of the training session. The main reason for the stretching exercises at the end of the sessions is the development of flexibility and muscle relaxation (Sands et al., 2013).

Many debates occur regarding the application of static stretching exercises at the end of the training sessions as a recuperation strategy, but there are no convincing data that static stretching exercises affect the recuperation of football players (Sands et al., 2013; Nedelec et al., 2013); only 50% of professional clubs of France apply static stretching at the end of the training as a strategy for recuperation (Nedelec et al., 2013).

From the research to date, we understand that it is not enough only to prove that applying static stretching exercises during the end of the training sessions should be applied only with football players of young age but to see which is the effect of these exercises on other motor skills.

From the above data, it is necessary to conduct experimental research to prove the impact of flexibility exercises (static stretching) on the motor skills of young football players.

The primary goal of this study was to ascertain the impact of flexibility exercise (static stretching) applied during a recovery stage of the training session (cool-down) on the motor abilities of young football players (age range 11–17).

Methods

To accomplish this research, all samples were initially conducted at a medical control centre of sports medicine in Pristina and confirmed that all the players are sufficiently healthy to train for football and, in accordance with the Helsinki Declaration, all participants were informed about the purpose and procedures of testing and experimental treatment.

Participants

In this study, 68 young players of 11 to 17 years (beginners U13, n=20; pioneers U15, n=24; and cadets U17, n=24) participated, from the Ramiz Sadiku Football Club in Pristina.

Procedures

To achieve this objective, the participants were divided into control and experimental groups. The control group was composed of 34 football players of the following categories: beginners U13 (n=10; age 11.9±0.5; body weight 42.36±7.29; body height 153.8±7.8), pioneers U15 (n=12; age 14±0.4; body weight 52.3±8.9; body height 169±9.6), and cadets U17 (n=12; age 15.6±0.4; body weight 61.1±10.2; body height 175.7±6.4); the experimental group was composed of 34 football players of the following: beginners U13 (n=10; age 12.0±0.4; body weight 38.91±5.5; body height 151.8±6.1), pioneers U15 (n=12; age 13.8±0.5; body weight 53.45±8.48; body height 167.8±7.6), and cadets U17 (n=12; age 15.9±0.6; body weight 62.7±7.6; body height 176.7±6.7). Both groups were compared at the initial and the final measurements. The initial testing took place before the beginning of the pre-season while the final testing was performed at the end of the season (after four months of intervention with static stretching exercise).

All measurements were performed on parquet flooring in College Sports “Universi” in Prishtina at the same time and day, with a specialized framework and directly with the participation of the author of the study.

After 10 minutes of warm-up, all participants (players) in this study underwent testing variables of motor abilities for flexibility (Sit-and-Reach test), explosive strength (Vertical Jump - Maximal Counter Movement Jump-CMJmax), speed (sprint 5 m, 10 m and 30 m) and agility (20 m running zig-zag with and without a ball).

The flexibility (Sit-and-Reach test) test measures the flexibility of the lower back and hamstring muscles. The test was conducted indoors using a static sit-and-reach box, supplied with a tape measure. The participant was given the instruction to sit with legs together and extended in front of him, so that the feet (shoes off) touch the first step. Both knees were held together and flat on the floor. The scale (in centimetres) for measuring the distance was drawn on the first step. The end of the feet (i.e., the beginning of the step representing the starting point of the scale) was regarded as point zero). All measurements, in centimetres, above zero were positive, whereas the ones below, toward the knees, were negative. The task was to perform the furthest possible front bend with arms extended, and hands on top of each other, palms facing downward. That position was held for 2s to measure the distance. The test was performed three times (3 trials). The maximal reach distance was recorded in centimetres for all three trials (Sermaxhaj, 2019; Fernandez, Sanchez, Rodriguez Marroyo, & Villa, 2016; Popovic, Radosav, & Molnar, 2009).

The explosive strength (Vertical Jump - Maximal Counter Movement Jump-CMJmax, the CJMmax) test begins in an upright posture with hips and body centre of mass lowering until knees become about 90° bent and with hands flexed at chest height in the function of momentum before a final vertical push. The test of vertical jump is realized on a tenziometric platform (Powertimer 300, Newtest Oy, Tyrnävä, Finland). The system used in this study consisted of a controlling computer and a high sensors-density of 84×95 cm (Gonçalves, Pavao, & Dohnert, 2013; Enoksen, Tønnessen, & Shalfawi, 2009).

The sprint test (5 m, 10 m, and 30 m) consisted of a 30 m track, with 5 m and 10 m split time recording. The photocells were placed at starting positions at 5 m, 10 m, and 30 m in the finish line test. Testing was completed from a standing start, with the front foot placed 30 cm behind the photocell’s start line. The test is realized with of Powertimer 300 (Newtest Oy, Tyrnävä, Finland) photocells with a precise time of 0.01 sec (Sander, Keiner, Wirth, & Shmidbleicher, 2013; Little & Williams, 2006; Verheijen, 1997).

The agility test of 20 m running zig-zag with and without the ball was completed from a standing start, with the front foot placed 30 cm behind the photocells' start line. The photocells were placed at the starting position and finish line test. This test was measured with Powertimer 300 testing system (Newtest Oy, Tyrnävä, Finland), with an exact time of 0.01 sec (Sermaxhaj, Arifi, Bahtiri, & Alaj, 2017b; Idrizovic, 2014; Little & Williams, 2006). All measurements were performed on parquet flooring at College Sports "Universi" of Pristina.

The programme of control and experimental group was realized within the frame of regular training of the Ramiz Sadiku Football Club. In the course of preparatory and competition period, the training programme was conducted three times per week, for both groups. Only the manner of the execution of the experimental programme was different (17 exercises of static stretching) for the development of flexibility, which was conducted within the frame of increased duration by the end of the training.

The protocol of control group was as follows: general and specific warm-up (15–20 min), the main part (35–45 min), cool down (10 min), recovery by running. Meanwhile, the protocol of the experimental group was as follows: general and specific warm-up (15–25 min), the main part (35-45 min), cool-down (25 min), which includes recovery by running (10 min) and static stretching (15 min) (Sermaxhaj et al., 2018). The experimental programme was developed by the author of the study based on recommendations of the other researchers in this area (Anderson, 2006; Walker, 2006).

The experimental programme consisted of 17 exercises of extension/static stretching upper body-flexibility exercises as follows: neck stretch upper back, chest and back, shoulder and mid-upper back, shoulder and triceps, lateral flexion right-left, and lower body flexibility exercises (hamstring two-leg stretch, Achilles and back stretch, quadriceps stretch, hamstring and groin stretch, standing groin stretch, groin stretch, chest stretch, stretch sitting hamstring, lower back stretch, the hamstring seat leg stretch, and Achilles tendon stretch. Each exercise was executed for 20 seconds (Sermaxhaj et al., 2018).

Statistical analysis

Data analyses were performed using SPSS version 21.0. The arithmetic mean and standard deviation were calculated for both groups with initial and final measurements for motor abilities (sit-and-reach test, CMJmax, sprint 5m, 10m, 30m, 20m zig zag with and without ball). Analyses of variance (ANOVA) are calculated differences between the arithmetic mean of each variable of control and experimental group before and after the experimental treatment (static stretching). The level of significance is p<.05.

Results

The parameters are shown in Table 1 for both groups (control and experimental) of initial and final measures.

Table 1. The significance of differences between arithmetic means of variables data of motor abilities of the control and experimental group of beginners (U-13), pioneers (U15) and cadets (17) at the initial measurement

Category	Variables	Control Group Mean± SD	Experimental Group Mean±SD	F	p level
beginners U13	Sit-and-Reach test	-1.00±7.37	-0.40±4.32	.049	.827
	CMJmax	31.93±4.27	29.62±4.14	1.506	.236
	Sprint 5 m	1.31±.12	1.35±.16	.322	.577
	Sprint 10 m	2.22±.13	2.17±.09	.796	.384
	Sprint 30 m	5.30±.36	5.37±.29	.220	.645
	20 m zig-zag without ball	7.21±.69	6.93±.31	1.29	.270
	20 m zig-zag with ball	9.04±.39	9.17±.66	.316	.581
pioneers U15	Sit-and-Reach test	.41±5.08	-1.41±8.2	.109	.520
	CMJmax	38.45±4.97	39.65±4.51	.427	.543
	Sprint 5 m	1.21±.12	1.22±.12	.002	.961
	Sprint 10 m	2.05±.16	2.12±.15	.023	.880
	Sprint 30 m	4.95±.39	4.91±.39	.074	.789
	20 m zig-zag without ball	7.00±.28	6.89±.36	.599	.447
	20 m zig-zag with ball	8.79±.54	8.47±.55	2.02	.169
cadets U17	Sit-and-Reach test	-3.25±5.4	1.58±7.9	3.00	.097
	CMJmax	38.30±3.7	38.95±4.9	.134	.718
	Sprint 5 m	1.21±0.09	1.23±0.12	.934	.344
	Sprint 10 m	1.92±0.09	1.95±0.16	1.50	.233
	Sprint 30 m	4.75±0.28	4.58±0.17	2.52	.126
	20 m zig-zag without ball	6.47±0.3	6.50±0.4	.028	.868
	20 m zig-zag with ball	7.99±0.6	7.97±0.4	.013	.912

The measurement data in Table 1 show that univariate analysis of variance (ANOVA) based on the coefficient value F-relations and statistical significance (significance) p-value are proved statistically insignificant among the control and experimental groups; this confirms the homogeneity of the groups' initial measurements.

All of the participants come from the same club; the control and experimental group belong to the same category. The selection of participants was based on their motor performance; therefore, there were no statistically significant differences between the control and experimental group to all three categories.

Table 2. The significance of differences between arithmetic means of variables data of motor abilities of the control and experimental group of beginners (U-13), pioneers (U15) and cadets (17) at the final measurement

Category	Variables	Control Group Mean± SD	Experimental Group Mean±SD	F	p level
beginners U13	Sit-and-Reach test	1.40±7.67	2.00±3.71	.050	.826
	CMJmax	34.89±6.62	31.46±4.14	1.924	.182
	Sprint 5 m	1.19±.07	1.21±.08	.678	.421
	Sprint 10 m	2.08±.10	2.04±.09	.556	.466
	Sprint 30 m	5.19±.41	5.23±.28	.081	.779
	20 m zig zag without ball	6.91±0.4	6.58±0.4	2.69	.118
	20 m zig zag with ball	8.75±0.9	8.27±0.5	2.05	.169
pioneers U15	Sit-and-Reach test	-.50±6.00	1.66±7.2	.635	.434
	CMJmax	38.78±5.23	39.93±6.44	.230	.636
	Sprint 5 m	1.20±.09	1.20±.15	.113	.740
	Sprint 10 m	2.04±.14	2.04±.15	1.472	.237
	Sprint 30 m	4.89±.33	4.90±.31	.001	.975
	20 m zig-zag without ball	6.75±.31	6.66±.43	.342	.565
	20 m zig-zag with ball	8.46±.62	8.35±.77	.126	.726
cadets U17	Sit-and-Reach test	-.41±3.5	6.25±7.6	7.49	.012
	CMJmax	43.34±3.7	41.51±4.0	.943	.342
	Sprint 5 m	1.18±0.10	1.14±0.09	.149	.704
	Sprint 10 m	1.92±0.08	1.88±0.07	.259	.616
	Sprint 30 m	4.66±0.20	4.55±0.16	1.73	.201
	20 m zig-zag without ball	6.23±.29	6.16±.33	.324	.575
	20 m zig-zag with ball	7.73±.52	7.73±.48	.000	.997

The final measurement data in Table 2 show that univariate analysis of variance (ANOVA) based on a coefficient F-relations and value of statistical significance p-value proves that between the control and experimental group statistically significant differences are only found in the flexibility variable (sit-and-reach test, on the level of p=.012) in favour of the experimental group of the cadet category, and without any positive or negative effect on the other motor skills variables.

Authentication of the difference between the control and experimental group only on the flexibility variable (sit-and-reach test) shows that the experimental programme (static stretching exercises) has caused positive changes only in the variable that characterizes the flexibility of cadet football players.

The research results show that the average flexibility variable value (sit-and-reach test) is different at young ages, beginners (2.00 cm), pioneers (1.66 cm), and cadets (6.25 cm), which proves that cadets have better results comparing to beginners and pioneers. It is understood that body flexibility peaks after 15 years of age, which corresponds with the previous research (Smajic, Molnar, & Popovic, 2009).

However, the results of this research show that the flexibility of these categories (beginners, pioneers and cadets), is lower than the flexibility of U19 football players of Croatia with an average value of 12.42 cm, which also is lower than the results of professional football players with average values of 8–18 cm and more (Milanovic, Sporis, Trajkovic, James, & Samija, 2013).

Discussion

The positive long-term effect of the application of static stretching exercises to the flexibility of the cadet category of football players is also proved by other authors (Fernandez et al., 2016; Gonçalves et al., 2013; Akbulut & Agopyan, 2015; Zakas, 2005).

With young football players, the non-effect of the long-term application of static stretching on motor skills is proved in speed 30 m (Fernandez et al., 2016; Bazett-Jones, Gibson, & McBride, 2008) and vertical jump (Gonçalves et al., 2013; Kinugasa & Kildinga, 2009), in agility with and without the ball (Brandey et al., 2012; Rey, Carlos, Luis, & Joaquin, 2012; Sermaxhaj et al., 2017b), in the isokinetic force (Sermaxhaj, Popovic, Bjelica, Gardasevic, & Arifi, 2017a; La Roche, Lussier, & Roy, 2008).

The results acquired show that the programme conducted for the development of flexibility (static stretching exercises) have a statistically significant effect only on the “sit-and-reach test” flexibility variable with the experimental group of cadets, and with no statistically essential influence on the motor abilities of beginners, pioneers, and cadets. Therefore, it can be confirmed that static exercises at the end of the training sessions have an essential effect on the improvement of flexibility of participants older than 15 years old, but without positive or negative effects on other variables of motor abilities of young players.

The results of this research present further development in recognizing when and in which manner the static stretching exercises should be implemented and their effect on the motor abilities of football players.

Furthermore, this research is of practical value especially in that it clearly explains whether flexibility exercise has a positive or negative impact on some specific motor abilities of young football players, and precisely recommend when to employ it.

Based on the data obtained from this research, we can suggest the application of static stretching exercises at the end of the training session (during the regeneration phase) on subjects older than 15 years old (after puberty), two to three times a week with the purpose of further optimal development of football players flexibility. For those younger than 15 years old, the application of combined dynamic and static stretching exercises is enough at the beginning of the training session (during the warm-up phase), and supplemental extension exercises can be programmed according to individual needs (before and after regular training sessions) with the purpose of the optimal development of football players' flexibility.

Acknowledgements
The researchers are grateful to Jeton Havolli from the College Universi Pristina for his contribution for organizing the measurements.

Conflicts of interest
The authors declare that there are no conflicts of interest.

Received: 11 July 2020 | **Accepted:** 28 August 2020 | **Published:** 01 February 2021

References

Akbulut, T., & Agopyan, A. (2015). Effects of an eight-week proprioceptive neuromuscular facilitation stretching program on kicking speed and range of motion in young male soccer players. *Journal of Strength and Conditioning Research, 29*(12), 3412–23.

Anderson, B. (2006). *Stretching*. Zagreb: Gopal.

Bazett-Jones, D., Gibson, M. H., & McBride, J. M. (2008). Sprint and vertical jump performances are not affected by six weeks of static hamstring stretching. *Journal of Strength and Conditioning Research, 22*(1), 25-31.

Behm, D. G., & Kibele, A. (2007). Effects of differing intensities of static stretching on jump performance. *European Journal of Applied Physiology, 101*(5), 587-594.

Behm, D. G., Chaouachi, A., Lau, P. W. C., & Wong, D. P. (2011). Short durations of static stretching when combined with dynamic stretching do not impair repeated sprints and agility. *Journal of Sports Science and Medicine*, *10*(2), 408-416.

Brandey, J., Ajit, D. K., Richard, S. F., & Jennifer, L. C. (2012). Acute effects of static and proprioceptive neuromusscular Facilitation Stretching on Agility performance in Elite Youth Soccer Players. *International Journal Exercises Sciences, 5*(2), 97-105.

Enoksen, E., Tønnessen, E., & Shalfawi, S. (2009). Validity and reliability of the Newtest Powertimer 300-series testing system. *Journal of Sports Sciences, 27*, 77–84.

Fernandez, R. A., Sanchez, J., Rodriguez Marroyo, J. A., & Villa, J. G. (2016). Effects of seven weeks of static hamstring stretching on flexibility and sprint performance in young soccer players according to their playing position. *Journal of Sport Medicine and Physical Fitness, 56*(4), 345-51.

Garcia-Pinillos, F., Ruiz-Ariza, A., Moreno del Castillo, R., & Latorre-Roman, P. A. (2015). Impact of limited hamstring flexibility on vertical jump, kicking speed, sprint, and agility in young football players. *Journal of sports sciences, 33*(12), 1293-1297.

Gardasevic, J., & Bjelica, D. (2013). Efekti programiranog trenažnog rada u trajanju od šest nedjelja na transformaciju gipkosti kod fudbalera kadetskog uzrasta. *Sport Mont, 11*(37-39), 212-217.

Gil, S., Ruiz, F., Irazusta, A., Gil, J., & Irazusta, J. (2007). Selection of young soccer players in terms of anthropometric and physiological factors. *Journal of sports medicine and physical fitness, 47*(1), 25-32.

Gonçalves, D. L., Pavao, T. S., & Dohnert, M. B. (2013). Acute and chronic effects of a static and dynamic stretching program in the performance of young soccer athletes. *Revista Brasileira de Medicina do Esporte, 19*(4), 241-246

Idrizovic, K. (2014). Physical and anthropometric profiles of elite female soccer players. *Medicina dello sport;* 67(2), 273-287.

Kay, D. A., & Blazevich, A. J. (2011). Effect of Acute Statik Stretch on Maximal Muscle Performance: A Systematic Review. *Medicine and Science in Sports and Exercise, 44*(1), 154-64.

Kinugasa, T., & Kilding, A.E. (2009). A comparison of post-match recovery strategies in youth soccer players. *Journal of Strength and Conditioning Research, 23*(5), 1402-07.

Kyranoudis, A., Nikolaidis, V., Ispirlidis, I., Galazoulas, Ch., Alipasali, F., & Famisis, K. (2018). Acute effect of specific warm-up exercises on sprint performance after static and dynamic stretching in amateur soccer players. *Journal of Physical Education and Sport, 18*(2), 825-830.

La Roche, D. P., Lussier, M., & Roy, S. J. (2008). Chronic stretching and voluntary muscle force. *Journal of Strength and Conditioning Research, 22*(2), 589-596.

Little, T., & Williams, A. G. (2006). Effects of differential stretching protocols during warm-ups on high-speed motor capacities in professional soccer players. *Journal of Strength and Conditioning Research, 20*(1), 203-207.

Lohman, T. G., Roche, A. F., & Martorell, R. (1988). *Anthropometric standardization reference manual.* Chicago: Human Kinetics Books.

Marfell-Jones, M., Olds, T., Stew, A. D., & Carter, J. E. L. (2006). *International standards for anthropometric assessment*. Potchesfstroom, International Society for the Advancement of Kinanthropometry.

Milanovic, Z., Sporis, G., Trajkovic, N., James, N., & Samija, K. (2013). Effect of a 12 Week SAQ Training Programme on Agility with and without the Ball among Young Soccer Players. *Journal of Sports Sciences and Medicine, 12*(1), 97-103.

Nedelec, M., McCall, A., Carling, C., Legall, F., Berthoin, S., & Dupont, G. (2013). Recovery in soccer. *Sports Medicine*, *43*(1), 9-22.

Popovic, S., Radosav. R., & Molnar, S. (2009). The effects of physical exercise on growth and deportment of strength in young football players. In *Proceedings book of the International Scientific Conference „Exercise And Quality Of Life"* (129-133). Faculty of Sport and Physical Education, Novi Sad.

Rey, E., Carlos, L. P., Luis, C. & Joaquin. L. B. (2012). The Effect of Immediate Post-Training Active and Passive Recovery Interventions on Anaerobic Performance and Lower Limb Flexibility in Professional Soccer Players. *Journal of Human Kinetics., 31*, 121-129.

Sands, W. A., McNeal, J. R., Murray, S. R., Ramsey, M. W., Sato, K., Mizuguchi, S., & Stone, M. H. (2013). Stretching and its effects on recovery. *Strength and Conditioning Juarnal, 35*(5), 30-36.

Sander, A., Keiner, M., Wirth, K., & Shmidbleicher, D. (2013). Influence of a 2-year strength training programme on power performance in elite youth soccer players. *European Journal of Sport Science, 13*(5), 445-51.

Sermaxhaj, S., Popovic, S., Bjelica, D., Gardasevic. J., & Arifi, F. (2017a). Effect of recuperation with static stretching in isokinetic force of young football players. *Journal of Physical Education and Sport, 17*(3), 1948-53.

Sermaxhaj, S., Arifi, F., Bahtiri, A., & Alaj, I. (2017b). The Impact of Recuperation with Static Stretching in Flexibility And Agility with and without ball of Young Soccer Players. *Acta Kinesiologica, 11*(1), 33-38.

Sermaxhaj, S., Arifi, F., Alaj, I., Bahtiri, A., Havolli, J., & Sermaxhaj, S. S. (2018) The Effect of Static Stretching in Agility and Isokinetic Force at Football Players. *Sport Mont, 16*(2), 45-49.

Sermaxhaj, S. (2019). *The Impact of Physical Exercise on the Flexibility Program in the Anthropological Status of Young Footballers*. Unpublished Doctoral Dissertation. Niksic: University of Montenegro, Faculty for Sport and Physical Education.

Smajic, M., Molnar, S., & Popovic, S. (2009b) Effects of training process on flexibility of young footballers. *In Proceedings book of the International Scientific Conference „Exercise and quality of life"* (135-141). Novi Sad: Faculty of Sport and Physical Education u Novi Sad.

Vänttinen, T., Blomqvist, M., Nyman, K., & Hakkinen, K. (2011). Changes in body composition, hormonal status, and physical fitness in 11, 13, and 15-year-old Finnish regional youth soccer players during a two-year follow-up. *Journal of Strength and Conditioning Research, 25*(12), 3342-51.

Verheijen, R. (1997). *Handbuch fur Fussballkondition*. Amsterdam: Leer, BPF Versand.

Walker, B. (2006). *The anatomy of stretching*. Chichester: Lotus.

Zakas, A. (2005). The effect of stretching duration on the lower-extremity flexibility of adolescent soccer players. *The Journal of Bodywork and Movement Therapies, 9*(3), 220-225.

DOI 10.26773/smj.210202

ORIGINAL SCIENTIFIC PAPER

Relations of the Weekly External Training Load Indicators and Running Performances in Professional Soccer Matches

Toni Modric[1], Sime Versic[1] and Damir Sekulic[1]

[1]University of Split, Faculty of Kinesiology, Split, Croatia

Abstract

The aim of this study was (i) to examine associations between training load during the week and match outcomes; (ii) to evidence position-specific differences between playing positions of training load and match running performances in top-level soccer/football. Training load and match running performances were evaluated through external load parameters: total-distance-covered, distance covered by walking, jogging, running, high-intensity-running (high-speed-running + sprinting); the number of accelerations, high-intensity-accelerations, decelerations, and high-intensity- decelerations. All data were obtained via the Global Positioning System from twelve matches of the highest-level Croatian soccer competition and from training sessions in the preceding weeks. The players (age: 23.57±2.84 years) were divided into five playing positions: central defenders (n=18), full-backs (n=20), central midfielders (n=26), wing midfielders (n=5) and forwards (n=9). Significant ANOVA differences (p<0.05) were found in all external match load variables, while in weekly training sessions only in high-intensity-running, high-intensity-accelerations, and high-intensity- decelerations distinguished players across their playing positions. Inverse correlation for most of the external load parameters and positive correlation for the number of training sessions with match outcome was evidenced. Chances of positive match outcome were greater in weeks when the team participated in fewer training sessions and consequently had lower values of external training load.

Keywords: *football, training load, game load, relationships, conditioning, performance analysis*

Introduction

Soccer (football) is characterized by numerous dynamic activities' cyclic and acyclic movements (Gardasevic & Bjelica, 2019). The physical demands of elite soccer matches have increased substantially over the previous decade (Bradley et al., 2016). With regards to the different tactical roles, these demands vary according to the different playing positions (Di Salvo, Gregson, Atkinson, Tordoff, & Drust, 2009; Mallo, Mena, Nevado, & Paredes, 2015; Modric, Versic, Sekulic, & Liposek, 2019; Mouloud, 2019). Previous studies have provided detailed information about the position-specific running performances (Sarmento et al., 2014). In brief, it was highlighted that midfielders cover the highest total distance and players that play by the sides of the field (e.g., full-backs and wing midfielders) cover the greatest distances in high-intensity running (Di Salvo et al., 2007; Modric et al., 2019).

With the increased physical demands of soccer matches, optimal physical preparation of players became an indispensable part of professional soccer (Andrzejewski, Konefał, Chmura, Kowalczuk, & Chmura, 2016), while the monitoring of the training load turned out to be a key factor for accurate control of the training process (Rebelo et al., 2012). Specifically, an accurate evaluation of training load is paramount for the planning and periodization of training, especially with regard to the prevention of undertraining or overtraining, and ensuring that athletes are in an optimal condition for competition (Rebelo et al., 2012).

Correspondence:

T. Modric
University of Split, Faculty of Kinesiology, Teslina 6, 21000 Split, Croatia
E-mail: toni.modric@yahoo.com

Training load can be differentiated into external and internal loads. The external load can be derived from measurements of a player's movement on the pitch, and the internal load is related to the physiological and psychological stresses imposed on the player's body (Jaspers, Brink, Probst, Frencken, & Helsen, 2017). Typically, measures of internal training load are heart rate-based training impulse (TRIMP) and the session rate of perceived exertion (s-RPE) (Wallace, Slattery, & Coutts, 2014), while external training load is mostly evaluated with measures obtained from GPS or video-based technologies (i.e., total distance covered, different speed zone distance covered, accelerations and decelerations) (Scott, Lockie, Knight, Clark, & de Jonge, 2013).

Previous studies have described the in-season training periodization practices of elite soccer teams in detail. Briefly, Malone et al. (2015) and Stevens, de Ruiter, Twisk, Savelsbergh, and Beek (2017) reported lower training loads when training sessions approached match day. In a recent study, Oliveira et al. (2019) evidenced in-season external training load of UEFA Champions League team and indicated that total distance tended to decrease during the in-season (from 5589 m to 4545 m) (Oliveira et al., 2019). Akenhead, Harley, and Tweddle (2016) observed position-specific external training load of an English Premier League soccer team during training and found that some acceleration variables successfully differentiated playing positions with midfield players covering more distance within the total, low, and moderate acceleration thresholds than central defenders (Akenhead, Harley, & Tweddle, 2016). Clemente et al. (2019) reported that weeks with five training sessions had statistically more significant values for all external load ratios than weeks with three or four sessions.

The final achievement of the soccer game is assessed by match outcome (winning, losing or drawing). Therefore, it is not surprising that authors often search for the parameters that affect match outcome (Oberstone, 2009; Tenga & Sigmundstad, 2011). Several attempts have been made to determine performance indicators that may distinguish winning from losing teams (Oberstone, 2009; Tenga & Sigmundstad, 2011). Consequently, the essential aspects of final performance and achievement were technical indicators (Rampinini, Impellizzeri, Castagna, Coutts, & Wisløff, 2009), tactical- (Taylor, Mellalieu, & James, 2005), physical indicators (Gregson, Drust, Atkinson, & Salvo, 2010), and situation variables (Taylor, Mellalieu, James, & Barter, 2010). Although these studies provided a great deal of valuable information, there is an evident lack of studies that examined the training load parameters as factors of possible influence on match outcomes.

While there is a growing interest for the analysis of how running match performances (i.e., external match load) affect match outcome, to the best of our knowledge, there is no study that has explored the association between external training load from weekly sessions and match outcomes in soccer. Interestingly, authors from other sports (e.g., ice hockey and Australian soccer) have focused on this issue and reported valuable results for their sports (Douglas et al., 2019; Sullivan et al., 2014).

Therefore, the main objective of this study was to examine possible associations between external training load during the week and the match outcomes. Additionally, we examined position-specific training loads, game loads, and training/match ratio for studied soccer players. Altogether, these findings will provide better insight and understanding of the weekly external training sessions' load effects on success in soccer. Consequently, it could positively affect a team's possibility of winning the matches.

Methods

Participants and design

In this research, 77 training running performances were analysed as well as match performances of the same players at the end of the following week. All data were collected during 12 matches of the 2019/2020 season and during training sessions. In the observed period, the team played 7 home and 5 guest matches, with 8 wins, 2 draws, and 2 losses. Players (age: 23.57±2.84 years; body height: 181.9±5.17 cm; body mass: 78.36±4.18 kg) were divided into five different groups depending on playing positions: central defenders (n=18), full-backs (n=20), central midfielders (n=26), wide midfielders (n=5), and forwards (n=9); only players that played the whole game and participated on all training sessions in the week before each match were included in the study. This study was approved by the Ethics Board.

Procedures

The variables observed in this study were running parameters obtained during (i) game and (ii) training over the preceding week, playing position (central defenders, full-backs, central midfielders, wide midfielders, forwards), number of training session performed each week, home/guest match, and final match outcome (win, draw, lost)

Running performances observed in the study were: total distance covered (m); distance in five speed categories (walking (<7.1 km/h), jogging (7.2-14.3 km/h), running (14.4–19.7 km/h), high speed running (19.8–25.1 km/h), and sprinting (>25.2 km/h)); total accelerations (>0.5 m/s^2); high-intensity accelerations (>3 m/s^2); total decelerations (< (-) 0.5 m/s^2) and high-intensity decelerations (< (-) 3 m/s^2). For collecting data, GPS technology (Catapult S5 and X4 devices, Melbourne, Australia) with a sampling frequency of 10 Hz was used. The reliability and validity of the equipment had previously been confirmed in studies (Castellano, Blanco-Villaseñor, & Alvarez, 2011; Johnston, Watsford, Pine, & Spurrs, 2014).

Statistics

The normality of the distributions was checked with a Kolmogorov-Smirnov test, and data are presented as the means ± standard deviations. Differences between playing positions in running variables were analysed using a one-way analysis of variance (ANOVA) with Scheffe posthoc test. The ANOVA calculations were done separately for game-load and training-load variables. Associations between running parameters obtained at training and games were identified with Pearson's coefficient of correlation. Logistic regression for binary outcome was calculated in order to identify the association between running performances achieved at training during the preceding week and match outcome. The match outcome was binarized, and a won match was considered to be a "positive outcome" (coded as "2"), while the remaining two outcomes (loss and draw) were considered to be "negative outcomes" (coded as "1"). The logistic regression was controlled for covariate "home/guest match", since it was expected that there is a strong influence of this variable on match outcome, with a lower likelihood for a positive outcome for guest matches. In addition to running performances, the correlation was calculated between the number of training sessions in a week and match outcome (criterion). The Odds Ratio (OR), and 95% Confidence Interval (95%CI) were reported for each predictor (running performance). For all analyses, Statistica 13.0 (TIBCO Software Inc, USA) was used, and a p-level of 95% was applied.

Results

Significant ANOVA differences across playing positions ($p<0.05$) were found in all external match load variables. The greatest total distance (10,944 m) covered by central midfielders was significantly higher compared to almost all playing positions (e.g., when compared to central defenders, full-backs and forwards). The forwards covered the greatest distance in high-intensity running (894 m), while central defenders high-intensity distance covered (411 m) was significantly lower compared to all playing positions. The central midfielders carried out the highest number of accelerations and decelerations, while forwards carried out the highest number of high-intensity accelerations and decelerations (Table 1).

Table 1. Comparison of game running performance across playing positions

	Central defenders	Full backs	Central midfielders	Wide midfielders	Forwards	F-test (p)
	M±SD	M±SD	M±SD	M±SD	M±SD	
Total distance (m)	8880.2±512.3	9712.9±578.2	10944.6±615.9	10451.8±860.4	9625.9±471.4	36.59 (0.01)*
Low-intensity (walking + jogging) (m)	7539.0±417.5	7842.7±452.8	8727.7±535.4	8300.3±490.3	7495.6±348.3	23.50 (0.01)*
Running (m)	929.7±135.5	1150.1±128.5	1576.2±279.9	1328.3±230.7	1235.0±98.2	30.81 (0.01)*
High-intensity (high speed running + sprinting) (m)	411.3±111.8	709.4±123.5	644.2±184.2	823.3±284.3	894.0±195.4	16.60 (0.01)*
Accelerations (count)	395.2±58.8	387.7±89.9	477.3±53.5	434.5±59.7	393.0±39	7.30 (0.01)*
Decelerations (count)	396.0±64.7	401.8±40.7	471.7±48.3	429.5±71.7	398.2±35	8.63 (0.01)*
High-intensity accelerations (count)	12.7±3.3	11.9±4.2	10.8±4.8	10.3±3.3	30.0±8.3	29.24 (0.01)*
High-intensity decelerations (count)	27.4±6.7	29.9±7.9	34.2±10.6	36.5±14.2	50.9±5.2	11.93 (0.01)*

Legend: M – Mean; SD - Standard deviation; * - significant difference

The greatest weekly total distance was covered by forwards (19,829 m) and central midfielders (19,095 m), but no significant differences across playing positions were found. The highest amount of high-intensity running was performed by full-backs players (742 m), while the lowest was performed by central midfielders (428 m), with significant posthoc difference between full-backs and central midfielders. The forwards and central defenders carried out the highest number of total accelerations/decelerations and high-intensity accelerations/decelerations (Table 2).

Table 2. Comparison of running performance in weekly training sessions across playing positions

	Central defenders	Full backs	Central midfielders	Wide midfielders	Forwards	F-test (p)
	M±SD	M±SD	M±SD	M±SD	M±SD	
Total distance (m)	18070.4±4161.7	17531.7±5376.4	19095.9±5523	18880.0±5391	19829.0±6294.8	0.43(0.79)
Low-intensity (walking + jogging) (m)	16071.4±3750.9	15271.3±4893.4	16999.3±4783.6	16589.8±4514.9	17348.4±5562.4	0.51(0.73)
Running (m)	1468.9±336.1	1517.4±423.4	1681.3±841.1	1609.8±627.5	1826.1±651.3	0.70(0.59)
High-intensity (high speed running + sprinting) (m)	529.5±204.4	742.9±253.9	428.9±278.6	679.8±390.8	654.3±227	4.76(0.01)*
Accelerations (count)	802.4±214.5	707.6±235.8	794.0±320.4	735.0±342.5	895.6±324.5	0.79(0.53)
Decelerations (count)	799.7±207.5	697.1±235.1	804.8±287.6	801.3±242.7	887.2±324.5	0.98(0.43)
High-intensity accelerations (count)	32.5±13.1	25.3±9.2	15.8±7.1	24.3±12.2	31.6±12.3	8.65(0.01)*
High-intensity decelerations (count)	63.1±25.8	41.1±11.6	35.1±21.5	35.0±17.5	66.7±27.2	7.30(0.01)*

The highest training/match ratio was evidenced for the total number of accelerations (2.09), distance covered at low speeds (7.1-14.3 km/h) (2.04) and high-intensity accelerations (2.01) total number decelerations (1.87), and for total distance covered (1.87) (Figure 1). The training/match ratio for distance covered while running at medium speed (14.4–19.7 km/h) and high speeds (19.8+ km/h) was 1.31 and 0.92, respectively (Figure 1).

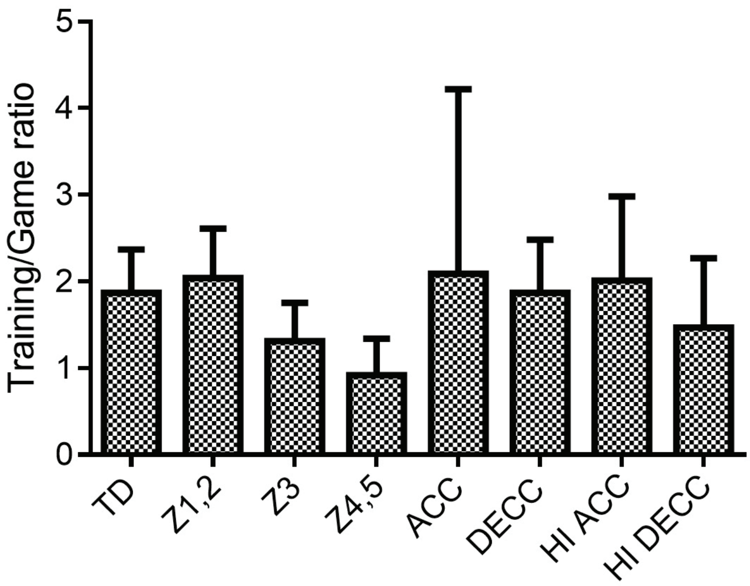


FIGURE 1. Training/match running performance ratio

Legend: TD – total distance; Z1,2 – low intensity running; Z3 – running; Z4,5 – high intensity running; ACC – acceleration; DECC – deceleration; HI ACC – high intensity accelerations; HI DECC – high intensity decelerations

The total distance covered (r=0.25), distance covered in running zone (r=0.39), high-intensity distance covered (r=0.48), high-intensity number of accelerations (r=0.43) and decelerations (r=0.39) from weekly training sessions were significantly correlated with values of associated match variables (Table 3).

Table 3. Pearson's correlation coefficients between running performance and weekly training performance of the corresponding variables

	Total distance (G)	Low-intensity running (G)	Running (G)	High-speed running (G)	Sprint (G)	High-intensity running (G)	Total accelerations (G)	Total decelerations (G)	High intensity-accelerations (G)	High-intensity decelerations (G)
Total distance (W)	0.25*	0.16	0.25*	0.29*	0.02	0.22	0.08	0.13	0.29*	0.30*
Low intensity (walking + jogging) (W)	0.25*	0.19	0.23*	0.25*	-0.02	0.17	0.09	0.14	0.27*	0.26*
Running (W)	0.27*	0.09	0.39*	0.45*	0.11	0.38*	0.15	0.17	0.35*	0.45*
High-intensity (high speed running + sprinting) (W)	-0.07	-0.26*	0.01	0.37*	0.51*	0.48*	-0.34*	-0.26*	0.21	0.25*
Total accelerations (W)	0.18	0.07	0.25*	0.28*	0.02	0.21	0.13	0.16	0.37*	0.39*
Total decelerations (W)	0.22	0.12	0.27*	0.28*	-0.00	0.20	0.15	0.21	0.36*	0.38*
High-intensity accelerations (W)	-0.41*	-0.48*	-0.30*	-0.02	0.33*	0.12	-0.28*	-0.30*	0.43*	0.23*
High-intensity decelerations (W)	-0.27*	-0.37*	-0.11	0.08	0.18	0.13	-0.18	-0.22	0.50*	0.39*

Legend: * - significant correlation

Table 4 presents the results of logistic regression for the binary outcome measure: match outcome. In general, most of the running performances in training were negatively related to the match outcome. Specifically, there is a lower likelihood for positive match outcome (e.g., winning the game), if players in weekly training sessions achieved higher: total distance covered (OR: 0.98; 95%CI: 0.98-0.99), low intensity (walking + jogging) distance covered (OR: 0.99, 95%CI: 0.97-0.99), running zone distance covered (OR: 0.99; 95%CI: 0.98-0.99), Z4W (OR: 0.97; 95%CI: 0.96-0.99), high-intensity (high speed running + sprinting) distance covered (OR: 0.98; 95%CI: 0.97-0.99), total number of accelerations (OR: 0.99; 95%CI: 0.98-0.99), total number of decelerations (OR: 0.98; 95%CI: 0.96-0.99), more high-intensity accelerations (OR: 0.96; 95%CI: 0.95-0.99), and more high-intensity decelerations (OR: 0.98; 95%CI: 0.97-0.99). To summarize, such associations were all generated by higher numbers of training sessions in weeks when the observed team played a game away from home (OR: 0.14, 95%CI: 0.05-0.35)

Table 4. Logistic regressions between running performance during week and number of training sessions with match outcome

	OR	95%CI
Total distance	0.98	0.98-0.99
Low intensity (walking + jogging)	0.99	0.98-0.99
Running	0.99	0.98-0.99
High intensity (high speed running + sprinting)	0.98	0.97-0.99
Total number of accelerations	0.99	0.98-0.99
Total number of decelerations	0.98	0.96.0.99
High-intensity accelerations	0.96	0.95-0.99
High-intensity decelerations	0.98	0.97-0.99
Training sessions per week	0.14	0.05-0.35

Discussion

There are several significant findings of this study, which will be discussed in the following. First, playing positions differed considerably in specific running performances during training and matches. Next, the results indicated significant correlations between corresponding running performances obtained at training and match. Finally, the training load was significantly associated with the match outcome.

Differences among playing positions in running performances

Our results evidenced significant differences between playing positions for total distance covered in soccer matches. These findings are in accordance with the results of previous studies in which authors reported that distance covered during the match varies considering the position-specific tactical roles (Di Salvo et al., 2007; Modric et al., 2019). In detail, while central defenders covered the lowest total distance (8880 m in average), central midfielders total distance covered (10,944m in average) was statistically greater compared to central defenders, full-backs and forwards (p<0.05). Similar results are discussed in previous studies in which it was reported that central midfielders usually cover significantly more distance than players in all other playing positions due to their tactical roles (Di Salvo et al., 2007; Modric et al., 2019).

It has already been noted that high-intensity distance covered (above speeds of 20 km/h) in matches is one of the most important elements in successful soccer performance (Di Salvo et al., 2009). Specifically, external players (wide midfielders and full-backs) and front players (forwards) cover the greatest amount of high-intensity distance (Di Salvo et al., 2007; Mallo et al., 2015). Our results indicated that central defenders high-intensity distance covered is statistically lower when compared to all other playing positions (p<0.05), while the greatest amount of high-intensity distance in matches was covered by forwards (894 m in average), followed by wide midfielders and full-backs (823 m and 709 m, respectively). Therefore, we may say that our findings are in accordance with previous studies when authors reported similar results for Italian Serie A, Spanish La Liga, and English Premier League (Di Salvo et al., 2007; Di Salvo et al., 2009; Mallo et al., 2015).

The central midfielders have the highest numbers of accelerations and decelerations in the soccer matches (on average 477 and 471, respectively), while forwards have the highest number of high-intensity accelerations and decelerations (in average 30 and 50, respectively). In general, it is difficult to compare our acceleration data with the literature, since there is currently little consensus regarding the use of acceleration thresholds in team sports (Johnston et al., 2014). Moreover, a comparison between acceleration variables measured with different tracking systems (and system versions) would also be difficult (Buchheit et al., 2014).

Although we did not find evidence of significant differences between playing positions, forwards and central midfielders tend to have the highest average weekly total distance (19,829 m and 19,095 m in average, respectively), while full-backs have the lowest (17,531 m in average). The greatest weekly high-intensity distance covered by full-backs (742 m on average) was higher compared to central midfielders, which covered the lowest distance at high speeds through weekly training sessions. Accordingly, it seems that full-backs weekly training drills contain more high-intensity running, while conversely, central midfielders training sessions tend to stimuli greater distance covered without many high-intensity efforts. Furthermore, our results evidenced that central midfielders has the lowest number of high-intensity accelerations (n=15) and decelerations (n=35). As already reported that central midfielders soccer success is more influenced by soccer variables (Modric et al., 2019), it seems that central midfielders training sessions are generally more focused on soccer skills than on running performances.

Training/match ratio

Compared to running performances from the matches, the average total distance from weekly training sessions was higher by 1.74 times for central midfielders, 1.81 times for wide midfielders, 1.80 for full-backs, 2.04 times for central defenders and 2.05 for forwards. Weekly high-intensity distance covered for full-backs and central defenders was higher (1.05 and 1.30 times, respectively), while for central midfielders, wide midfielders and forwards it was lower (0.63, 0.81, and 0.77, respectively) compared to match values. Acceleration/deceleration load were higher in weekly training sessions compared to the match values. Specifically, the training/match ratio was 2.09 for the total number of accelerations, 1.87 for the total number of decelerations, 2.01 for of high-intensity accelerations and 1.47 for of high-intensity decelerations. This suggests that, through weekly training sessions, the total distance covered and accelerations/decelerations were more emphasized than the high-intensity distance covered. Similar findings were previously discussed in the recent study of Clemente et al. (2019), in which it was presented that "specific variables (e.g. high-speed running distance and sprinting distance) were associated with substantially lower ratios than other variables".

Correlates of match outcome

A strong correlation between the weekly number of training sessions and match outcomes indicated a higher possibility for winning the matches when preceding weeks had lower numbers of training sessions. Furthermore, our results evidenced an inverse association of almost all running performances in weekly training sessions with match outcomes. These findings emphasize that external weekly load values were lower when the team won in subsequent matches. Since it previously was highlighted that the higher weekly number of training sessions provoke a higher weekly external training load (Clemente et al., 2019), a team's positive achievement would be greater in weeks with lower numbers of training sessions and lower values of external training load.

Typical training sessions in weeks with short time until the next games (i.e., weeks with lower numbers of training sessions) are more focused on the recovery and development of soccer skills (e.g., technical and tactical skills) than on strength and conditioning (i.e., adaptation of conditioning abilities cannot be optimal if there is a short period between matches). Consequently, in such weeks the players experienced less external training load, which possibly resulted in better recovery and superior overall fitness status in subsequent matches. Altogether, it allowed players to execute technical and tactical requirements during game situations at a higher level (Borges et al., 2017). Collectively, it logically could result even in better overall achievement and, finally, positive results.

Supportively, previously it was highlighted that soccer players' work rate was lower when winning than losing a match (Castellano et al., 2011). Also, low-ranked teams have greater high-intensity distance covered compared to top-ranked teams (Di Salvo et al., 2009; Rampinini et al., 2009). Considering the results of our study in which we evidenced correlation for almost all running parameters (e.g., total distance covered, high-intensity distance covered, distance covered in the zone of running, number of high-intensity accelerations and decelerations) obtained at training and matches, it seems that external load in matches was affected with external load from training sessions. In other words, if players perform lower external load values in training, lower values of associated external load variables will occur in matches. In accordance with previously cited studies, this could imply that positive results were more affected with technical and tactical skills than with running performances from both training sessions and matches.

Strengths and limitations

This study was based on results obtained from a team in Croatian competition (top-level competition in the country); therefore, results may be generalized to similar qualitative ranks. Also, we did not present any specific data about physical conditioning status, which will allow more detailed discussion. Finally, in this study, we included only those players who participated in all matches and all training sessions; this was necessary due to methodological reasons. Meanwhile, this is one of the first studies where training running performances were simultaneously correlated with: (i) match running performances, and (ii) match outcome. Also, the level of players observed is a significant strength of the investigation. Finally, throughout the study, the same team of professionals (coaches, physicians) managed the observed team, which consequently reduced the possibility that factors other than those observed influenced the results of the study.

The results of this study confirmed that most of the variables of external match load in soccer vary according to the different playing positions. Through weekly training sessions, variables that determine intensity (e.g., high-intensity distance covered (+19.8 km/h), and the number of high-intensity accelerations/decelerations) distinguished players between their playing positions, while no differences were found for volume variables (e.g. total distance covered and the total number of accelerations and decelerations), low-intensity variables (e.g., walking + jogging) and moderate-intensity variables (e.g., distance covered in the zone of running).

Since training/match ratios were higher for total distance covered, distance covered in low speeds, the number of total accelerations/decelerations and the number of high-intensity accelerations, it seems that these variables were more stimulated through training sessions than distance covered at moderate (14.4–19.7 km/h) and high speeds (+20 km/h).

Positive correlations between some external training and match load variables highlighted that if a team performs higher values of total distance covered, distance covered in the running zone, high-intensity distance covered, high-intensity number of accelerations and decelerations in weekly training sessions, higher values of same variables will occur in subsequent matches.

Finally, correlations between the weekly number of training sessions and weekly running performances with match outcome demonstrated that the chances of positive achievement at the game were greater in weeks when the team participated in fewer training sessions and consequently had lower values of external training load.

Acknowledgements
There are no acknowledgements.

Conflict of Interest
The authors declare the absence of conflict of interest.

Received: 14 March 2020 | **Accepted:** 21 May 2020 | **Published:** 01 February 2021

References

Akenhead, R., Harley, J. A., & Tweddle, S. P. (2016). Examining the external training load of an English Premier League football team with special reference to acceleration. *Journal of strength and conditioning research, 30*(9), 2424-2432.

Andrzejewski, M., Konefał, M., Chmura, P., Kowalczuk, E., & Chmura, J. (2016). Match outcome and distances covered at various speeds in match play by elite German soccer players. *International Journal of Performance*

Analysis in Sport, 16(3), 817-828.

Borges, P. H., Rechenchosky, L., Paulo Deprá, P., Vaz Ronque, E. R., Juan Greco, P., Menezes Menegassi, V., & Rinaldi, W. (2017). Impact of Aerobic Power, Strength of Lower Limbs and Speed on Technical Skills in Young Soccer Players. *Journal of Exercise Physiology online, 20*(1), 221-230.

Bradley, P. S., Archer, D. T., Hogg, B., Schuth, G., Bush, M., Carling, C., & Barnes, C. (2016). Tier-specific evolution of match performance characteristics in the English Premier League: it's getting tougher at the top. *Journal of sports sciences, 34*(10), 980-987.

Buchheit, M., Allen, A., Poon, T. K., Modonutti, M., Gregson, W., & Di Salvo, V. (2014). Integrating different tracking systems in football: multiple camera semi-automatic system, local position measurement and GPS technologies. *Journal of sports sciences, 32*(20), 1844-1857.

Castellano, J., Blanco-Villaseñor, A., & Alvarez, D. (2011). Contextual variables and time-motion analysis in soccer. *International journal of sports medicine, 32*(06), 415-421.

Clemente, F. M., Rabbani, A., Conte, D., Castillo, D., Afonso, J., Clark, T., . . . Knechtle, B. (2019). Training/Match External Load Ratios in Professional Soccer Players: A Full-Season Study. *International journal of environmental research and public health, 16*(17), 3057.

Di Salvo, V., Baron, R., Tschan, H., Montero, F. C., Bachl, N., & Pigozzi, F. (2007). Performance characteristics according to playing position in elite soccer. *International journal of sports medicine, 28*(03), 222-227.

Di Salvo, V., Gregson, W., Atkinson, G., Tordoff, P., & Drust, B. (2009). Analysis of high intensity activity in Premier League soccer. *International journal of sports medicine, 30*(03), 205-212.

Douglas, A., Johnston, K., Baker, J., Rotondi, M. A., Jamnik, V. K., & Macpherson, A. K. (2019). On-ice measures of external load in relation to match outcome in elite female ice hockey. *Sports, 7*(7), 173.

Gardasevic, J., & Bjelica, D. (2019). Shooting ball accuracy with u16 soccer players after preparation period. *Sport Mont, 17*(1), 29-32.

Gregson, W., Drust, B., Atkinson, G., & Salvo, V. (2010). Match-to-match variability of high-speed activities in premier league soccer. *International journal of sports medicine, 31*(04), 237-242.

Jaspers, A., Brink, M. S., Probst, S. G., Frencken, W. G., & Helsen, W. F. (2017). Relationships between training load indicators and training outcomes in professional soccer. *Sports medicine, 47*(3), 533-544.

Johnston, R. J., Watsford, M. L., Pine, M. J., & Spurrs, R. W. (2014). Standardisation of acceleration zones in professional field sport athletes. *International Journal of Sports Science & Coaching, 9*(5), 1161-1168.

Mallo, J., Mena, E., Nevado, F., & Paredes, V. (2015). Physical demands of top-class soccer friendly matches in relation to a playing position using global positioning system technology. *Journal of human kinetics, 47*(1), 179-188.

Malone, J. J., Di Michele, R., Morgans, R., Burgess, D., Morton, J. P., & Drust, B. (2015). Seasonal training-load quantification in elite English premier league soccer players. *International journal of sports physiology and performance, 10*(4), 489-497.

Modric, T., Versic, S., Sekulic, D., & Liposek, S. (2019). Analysis of the Association between Running Performance and Game Performance Indicators in Professional Soccer Players. *International journal of environmental research and public health, 16*(20), 4032.

Mouloud, K. (2019). Level of state anxiety among youth football players according different playing positions. *Sport Mont, 17*(1), 33-37.

Oberstone, J. (2009). Differentiating the top English premier league football clubs from the rest of the pack: Identifying the keys to success. *Journal of Quantitative Analysis in Sports, 5*(3).

Oliveira, R., Brito, J. P., Martins, A., Mendes, B., Marinho, D. A., Ferraz, R., & Marques, M. C. (2019). In-season internal and external training load quantification of an elite European soccer team. *PloS one, 14*(4), e0209393.

Rampinini, E., Impellizzeri, F. M., Castagna, C., Coutts, A. J., & Wisløff, U. (2009). Technical performance during soccer matches of the Italian Serie A league: Effect of fatigue and competitive level. *Journal of science and medicine in sport, 12*(1), 227-233.

Rebelo, A., Brito, J., Seabra, A., Oliveira, J., Drust, B., & Krustrup, P. (2012). A new tool to measure training load in soccer training and match play. *International journal of sports medicine, 33*(04), 297-304.

Sarmento, H., Marcelino, R., Anguera, M. T., CampaniÇo, J., Matos, N., & LeitÃo, J. C. (2014). Match analysis in football: a systematic review. *J Sports Sci, 32*(20), 1831-1843.

Scott, B. R., Lockie, R. G., Knight, T. J., Clark, A. C., & de Jonge, X. A. J. (2013). A comparison of methods to quantify the in-season training load of professional soccer players. *International journal of sports physiology and performance, 8*(2), 195-202.

Stevens, T. G., de Ruiter, C. J., Twisk, J. W., Savelsbergh, G. J., & Beek, P. J. (2017). Quantification of in-season training load relative to match load in professional Dutch Eredivisie football players. *Science and Medicine in Football, 1*(2), 117-125.

Sullivan, C., Bilsborough, J. C., Cianciosi, M., Hocking, J., Cordy, J., & Coutts, A. J. (2014). Match score affects activity profile and skill performance in professional Australian Football players. *Journal of science and medicine in sport, 17*(3), 326-331.

Taylor, B. J., Mellalieu, D. S., & James, N. (2005). A comparison of individual and unit tactical behaviour and team strategy in professional soccer. *International Journal of Performance Analysis in Sport, 5*(2), 87-101.

Taylor, B. J., Mellalieu, D. S., James, N., & Barter, P. (2010). Situation variable effects and tactical performance in professional association football. *International Journal of Performance Analysis in Sport, 10*(3), 255-269.

Tenga, A., & Sigmundstad, E. (2011). Characteristics of goal-scoring possessions in open play: Comparing the top, in-between and bottom teams from professional soccer league. *International Journal of Performance Analysis in Sport, 11*(3), 545-552.

Wallace, L., Slattery, K., & Coutts, A. J. (2014). A comparison of methods for quantifying training load: relationships between modelled and actual training responses. *European Journal of Applied Physiology, 114*(1), 11-20.

DOI 10.26773/smj.210208

ORIGINAL SCIENTIFIC PAPER

Post-Exercise Hypotension in Brazilian Jiu-Jitsu

Wesley Rodrigues Belo[1], Lucas Fenta de Castro[1], Diego Cesar Palmieri[1], Luiz Gustavo Dias dos Santos[1], Tomás Herrera-Valenzuela[2,3], Marco Antonio Ferreira dos Santos[1], Karsten Øvretveit[4] and Roberto Simão[1]

[1]Federal University of Rio de Janeiro, School of Physical Education and Sports, Rio de Janeiro, Brazil, [2]Universidad de Santiago de Chile, Physical Activity, Sports and Health Sciences Laboratory, Department of Medical Sciences, Santiago, Chile, [3]Universidad Santo Tomás, School of Sports Science, Department of Health, Santiago, Chile, [4]Norwegian University of Science and Technology, Department of Public Health and Nursing, Trondheim, Norway

Abstract

Hypertension is a leading preventable cause of morbidity and mortality worldwide. Exercise is a widely recommended treatment strategy that has been shown to cause both acute and chronic reductions in blood pressure. This study aimed to explore the potential therapeutic effects of Brazilian jiu-jitsu training by assessing blood pressure responses during and after technical sparring. Seven Brazilian jiu-jitsu practitioners (age: 24.0±3.5 years; height: 1.75±0.02 m; body mass: 76.0±4.2 kg; BMI: 24.5±0.9) were included in the study. The participants performed three five-minute technical sparring rounds. Auscultatory measurements of blood pressure were obtained at rest, one minute post-sparring, and every ten minutes for a total of 60 minutes of recovery time. Between rounds, acute increases in both systolic blood pressure ($p<0.0001$) and diastolic blood pressure ($p<0.0001$) were observed. In the subsequent recovery period, both systolic blood pressure and diastolic blood pressure increased at the ten-minute mark compared to baseline values, but then started to gradually decline, with systolic blood pressure dropping 10.0±4.1 ($p<0.0001$) and diastolic blood pressure 5.0±4.1 mmHg ($p=0.001$) after one hour of recovery. These findings indicate that technical Brazilian jiu-jitsu sparring induces significant post-exercise decreases in blood pressure and thus may have value as a non-pharmacological treatment strategy for the prevention and management of hypertension.

Keywords: *martial arts, combat sports, Brazilian jiu-jitsu, hypertension, blood pressure*

Introduction

Chronically high blood pressure (BP), or hypertension (HTN), is a leading preventable cause of morbidity and mortality worldwide. Most cases are primary, with no identifiable underlying cause, making treatment challenging. Approximately 20–24% of the world population have high BP, with over 500 million new cases since 1975 (Zhou et al., 2017). Since early-stage HTN rarely causes symptoms, many hypertensives go undiagnosed, which contributes to the burden of the disease. The level of arterial pressure at which HTN is diagnosed differs between guidelines; some consider a systolic BP (SBP) of 130 mmHg as high normal (Williams et al., 2018) while others classify it as stage 1 HTN (Whelton et al., 2017). However, a negative impact on cardiovascular and renal function can be observed at an SBP as low as 110 mmHg (Forouzanfar et al., 2017).

The management of HTN may include both antihypertensive drugs and non-pharmacological interventions, such as changes in diet and activity levels. Indeed, physical exercise is a widely recommended prevention and treatment strategy in HTN (Pescatello et al., 2004). The antihypertensive effects of physical activity appear to in part be mediated by an acute BP reduction of ~5–7 mmHg in hypertensives following exercise, known as post-exercise hypotension (PEH) (Pescatello, MacDonald, Lamberti, & Johnson, 2015). Blood pressure responses have previously been investigated in both aerobic exercise and resistance training (Domingos & Polito, 2018; Hecksteden, Grutters, & Meyer, 2013; Keese, Farinatti,

Correspondence:

K. Øvretveit
Norwegian University of Science and Technology, Department of Public Health and Nursing, Postboks 8905, N-7491 Trondheim, Norway
E-mail: karsten.ovretveit@ntnu.no

Pescatello, & Monteiro, 2011; Ruiz et al., 2011), with either modality seemingly inducing PEH, particularly in unmedicated individuals who use exercise as a preventive strategy (Carpio-Rivera, Moncada-Jimenez, Salazar-Rojas, & Solera-Herrera, 2016).

Brazilian jiu-jitsu (BJJ) is a grappling-based combat sport with a growing number of recreational and professional practitioners. The effort pattern of BJJ is characterized by aerobic work at lower intensities interspersed with short bursts of high intensity (Andreato, Follmer, Celidonio, & Honorato, 2016). Despite several investigations of athlete characteristics (Andreato, Lara, Andrade, & Branco, 2017; Øvretveit, 2018b) and effort patterns in BJJ (Andreato et al., 2016; Øvretveit, 2018a), data on the health benefits, included the BP responses, of BJJ practise is scarce. Prado and Lopes (2009) found acute increases in BP following 20 minutes of BJJ sparring. During the subsequent 90-minute recovery time, both SBP and diastolic BP (DBP) fell steadily until the 75-minute mark, when an elevation below pre-exercise values was observed. Borges et al. (2012) observed the acute physiological responses to single five-minute sparring rounds, with BP measures at rest (pre-sparring), one, five, and fifteen minutes post-sparring in a training session. A BP increase was observed one minute post-sparring, following a reduction below pre-sparring levels, indicating BJJ-induced PEH. Similarly, Simão et al. (2007) reported BP reductions following a 60-minute judo session, although these findings did not reach statistical significance.

Brazilian jiu-jitsu training typically includes a warm-up followed by technical drilling and sparring (Øvretveit, 2018a). These training components may exert different effects on BP; while warm-ups and technical training may be associated with the PEH typically observed following aerobic exercise, competitive sparring might increase BP due to factors such as increased tension and anxiety (Piskorska et al., 2016) and emotional stress (Munakata, 2018). Notably, previous research on BP responses in grappling does not distinguish between technical (light) sparring or competitive (hard) sparring. As opposed to technical sparring, competitive sparring may increase injury risk and hence be less suitable for regular practice. Accordingly, studies assessing the health benefits of low-risk technical sparring can be used to inform training strategies and health goals in the general BJJ population. To the best of our knowledge, no study to date has explored BP responses in BJJ training.

Thus, this study aimed to investigate training-induced BP in BJJ practitioners and assess the potential therapeutic effects of the sport. We hypothesized that BP would increase acutely after each round compared to resting values, followed by a significant and gradual decrease during the recovery period.

Methods

Participants

The study sample comprised seven male BJJ practitioners (age: 24.0±3.5 years; height: 1.75±0.02 m; body mass: 76.0±4.2 kg; BMI: 24.5 0.9) from the Federal Brazilian Jiu-jitsu School (Team Minerva) at the Federal University of Rio de Janeiro (UFRJ) holding the rank of blue (n=6) and purple belt (n=1), with 5.0±1.3 years of BJJ training experience. To limit the skill discrepancy between the participants, white, brown, and black belts were ineligible for participation. The study protocol was reviewed and accepted as a graduation project at UFJR. All participants were informed of the risks and benefits associated with the investigation and gave their written informed consent prior to participation.

Experimental design

Data were collected on two non-consecutive days (Figure 1). On the first day, height and body mass were obtained with a balance weighing scale with a stadiometer (Filizola, São Paulo, Brazil) in a sport science laboratory. The participants subsequently underwent a protocol familiarization session at martial arts gymnasium's dojo (UFRJ) followed by a recovery period of 48 to 72 hours before the main data collection. In the 24-hour period leading up to the sparring session, participants were asked to abstain from exercise, caffeine, chocolate, green tea, sugary soda, alcohol as well as thermogenic supplements and other stimulating substances such as amphetamines, theophylline, theobromine, and their derivatives.

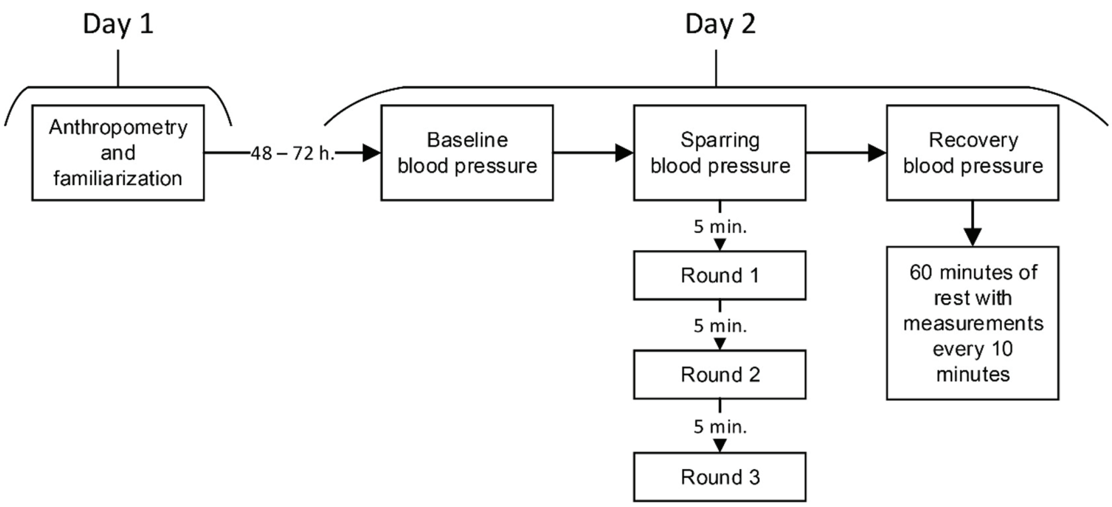


FIGURE 1. Experimental design

All BP measurements were obtained by trained personnel using a stethoscope (Duplex, Rudolf Riester GmbH, Jungingen, Germany) and sphygmomanometer (Premium, Wenzhou Kangju Medical Instrument Co., Ltd, Wenzhou, China). On the sparring day, baseline resting BP was measured in the seated position after ten minutes of rest. Subsequently, all participants completed three five-minute technical sparring rounds separated by five-minute breaks. The rounds were characterized by gentle movements without excessive use of muscular force, allowing a greater variety of attack and defence techniques without competitive purpose. When a submission position was achieved, a defence technique was allowed, and the combat continued until the end of time. Following the end of the last sparring round, the participants remained seated in a chair for 60 minutes, avoiding movement and talking. Blood pressure was measured one minute after each round and every ten minutes during the recovery period (Simão et al., 2007). Additionally, participants gave their rating of perceived exertion (RPE) on Borg's category-ratio scale (Borg, 1982) after each round.

Statistical analysis

Statistical analyses were performed using SPSS version 20 (Chicago, IL, USA). Figures were made using GraphPad Prism version 6 (San Diego, CA, USA). The Shapiro-Wilk test was used to test data normality. Differences in BP responses were assessed with repeated measures ANOVA followed by the Holm-Sidak post hoc test. Sphericity was assessed with Mauchly's test, with the Greenhouse Geisser test being used when necessary. To obtain the effect size, $Eta^2_{partial}$ (n^2) was used, calculated as $n^2 = SS_{between} / SS_{between +} SS_{residual}$. A 95% confidence limit was established. Data are presented as mean±standard deviation (SD). An alpha level of p≤0.05 was considered statistically significant for all comparisons.

Results

All participants successfully completed the designated sparring rounds. No adverse events occurred during any of the measurement procedures. Between sparring rounds, acute increases in both SBP ($F_{1.556, 9.336} = 102.6$; $n^2 = 0.972$; $p<0.0001$) and DBP ($F_{2.683, 16.10} = 30.04$; $n^2 = 0.913$; $p<0.0001$) were observed (Figure 2). This was accompanied by a gradual, albeit non-significant increase in RPE from 5.0±0.8 after round 1, to 6.0±1.4 after round 2, and peaking at 7.0±1.0 after round 3 ($F_{1.370, 8.218} = 3.205$; $n^2 = 0.590$; p=0.1037).

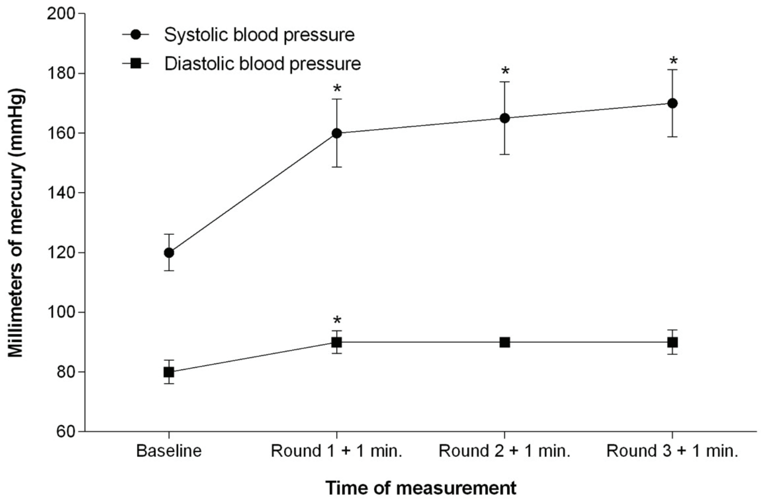


FIGURE 2. Blood pressure responses during sparring. Data presented as mean±SD. *Significant increase compare to baseline (p<0.05)

In the subsequent post-training recovery period, both SBP and DBP increased at the ten-minute mark compared to baseline resting values, but then started to gradually decline (Figure 3), with SBP dropping 10.0±4.1 ($F_{1.813, 10.88} = 39.16$; $n^2 = 0.931$; $p<0.0001$) and DBP 5.0±4.1 mmHg ($F_{1.790, 10.74} = 20.32$; ; $n^2 = 0.879$; p=0.001) after one hour of seated recovery.

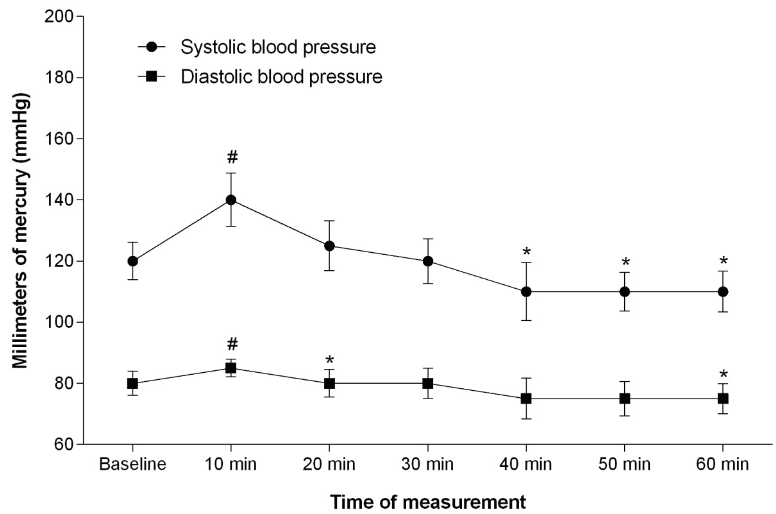


FIGURE 3. Blood pressure responses after sparring. Data presented as mean±SD. #Significant increase compare to baseline (p<0.05); *significant decrease compare to baseline (p<0.05)

Discussion

The increasing global prevalence and burden of HTN, and the well-established efficacy of physical exercise as an antihypertensive treatment strategy, warrants the investigation of various exercise modalities and their effects on BP. Thus, the present study sought to measure BP responses to controlled combat sports training in young, healthy adults. As hypothesized, our main finding was that both SBP and DBP decreased significantly following technical sparring, demonstrating a distinct PEH effect, which is in accordance with previous observations (Borges et al., 2012; Prado & Lopes, 2009; Simão et al., 2007) and indicates the efficacy of BJJ in the prevention and treatment of HTN.

Contrasting the observed increase ten minutes into recovery were the findings of Borges et al. (2012), who reported a reduction in SBP as early as five minutes after sparring. However, this may be due to differences in training volume, as the measurements were obtained after a single round of sparring, whereas we assessed recovery after three consecutive rounds. Furthermore, our findings on acute post-sparring (i.e., after one minute) increases in SBP are in agreement with previous observations (Borges et al., 2012; Prado & Lopes, 2009). The increasing RPE indicates cumulative fatigue as a result of consecutive bouts of sparring. Cumulative RPE in BJJ appears to be related to between-round recovery time, with short breaks leading to a progressive increase in perceived fatigue (Øvretveit, 2018a) while longer breaks result in similar RPE after consecutive bouts (Andreato et al., 2015). Accordingly, breaks during training can be adapted to the general training goals, e.g., extended to support recovery or narrowed to induce perceived fatigue. Although being considered as an appropriate method for training load quantification in combat sports, the subjective nature of the RPE measurement makes it susceptible to several factors such as the competitive level, external stimuli, training modalities, and intensity of the session (Slimani, Davis, Franchini, & Moalla, 2017). Thus, comparisons of studies and individual practitioners should be made with caution.

The magnitude of PEH after single bouts of exercise may be indicative of the long-term BP response to chronic exercise (Hecksteden et al., 2013). Accordingly, individual PEH may be used as an indicator of the degree of exercise-induced BP-reductions that can be expected over a given training period (Liu, Goodman, Nolan, Lacombe, & Thomas, 2012). Moreover, PEH likely plays an important role in the overall BP reductions caused by exercise training, highlighting the importance of regular physical activity (Pescatello et al., 2015). As demonstrated by the present study, light BJJ sparring elicits significant PEH effects and can, due to its relatively low physiological load, be performed with a high frequency without leading to overtraining and/or injury. However, exercise intensity has also been shown to be an important mediator of BP reductions (Boutcher & Boutcher, 2017) and exercise recommendations for the prevention and treatment of HTN must strike a balance between intensity, frequency, and volume of training. Although no study to date has compared the effects of light and hard sparring on PEH, BJJ practitioners have been shown to reach and maintain a relative heart rate (HR) of 85% during sparring at unrestricted intensities (Øvretveit, 2018a), which suggests that sparring can reach very high intensities, which has implications for exercise tolerance and subsequent adaptations. Thus, it might be appropriate to apply intensity restrictions to sparring sessions based on the goal of the practitioners. Importantly, while high-intensity sparring is often used for athletic conditioning, athletes who seek improvements in aerobic endurance should include alternative high-intensity conditioning approaches in their training plan (Øvretveit, 2019).

Although it is the type and degree of physiological stimulus rather than the specific exercise modality that generally should inform the balance of intensity, frequency and volume, BJJ practitioners must consider the inherent injury risk of the sport when they plan their training. Our findings suggest that low-intensity training is conducive to PEH and consequently can be appropriate for practitioners seeking BP reductions. Conversely, more competition-oriented practitioners may opt for a higher training intensity to more closely emulate the conditions of competition. While the injury rate in BJJ competition is reportedly lower than for other combat sports, such as taekwondo, judo, wrestling and mixed martial arts (Scoggin et al., 2014), injuries during BJJ training are very common (Petrisor et al., 2019). Furthermore, BJJ training intensity is thought to increase the risk of injury (Spano, Risucci, Etienne, & Petersen, 2019). Thus, inappropriate programming of high-intensity BJJ training may negatively affect both short- and long-term training adaptations and ultimately adherence to the sport. As the perceived risks and benefits of BJJ training may vary between practitioners, individual goals should govern the training plan. Considering that BJJ does not require athletic trainers or medical professionals to monitor practice sessions, the education of coaches and practitioners is important to minimize injury risk (Spano et al., 2019).

Exploring the underlying mechanisms of BP responses during and after exercise training is beyond the scope of this study, and the exact causes of the observed PEH remain to be determined. Indeed, the effects of exercise on the complex pathophysiology of HTN may be more appropriately explored in a different context. The study was limited by the small sample size and lack of objective intensity measurements during sparring, such as HR. To further elucidate the role of intensity in BJJ-mediated BP reductions, larger studies comparing different training intensities is needed.

In summary, technical BJJ sparring appears to lead to significant PEH, indicating its potential as a non-pharmacological approach to treat and prevent HTN. Although hard sparring can be appropriate for active competitors in preparation for competition, it might negatively impact BP through increased psychological stress, as well as increase the risk of injury. The relative safety and apparent effect of technical sparring on BP make it a compelling training approach for improvements in cardiovascular health.

Acknowledgements

This research was supported by Coordination for the Improvement of Higher Education Personnel (CAPES). The authors would like to thank the Federal Brazilian Jiu-jitsu School (Team Minerva) from the Federal University of Rio de Janeiro (UFRJ) for their participation in the study.

Conflict of Interest

The authors declare the absence of conflict of interest.

Received: 06 April 2020 | **Accepted:** 11 June 2020 | **Published:** 01 February 2021

References

Andreato, L. V., Follmer, B., Celidonio, C., & Honorato, A. (2016). Brazilian jiu-jitsu combat among different categories: time-motion and physiology. A systematic review. *Strength Cond J, 38*, 1. doi:10.1519/SSC.0000000000000256

Andreato, L. V., Julio, U. F., Goncalves Panissa, V. L., Del Conti Esteves, J. V., Hardt, F., Franzoi de Moraes, S. M., . . . Franchini, E. (2015). Brazilian jiu-jitsu simulated competition part II: physical performance, time-motion, technical-tactical analyses, and perceptual responses. *J Strength Cond Res, 29*(7), 2015-2025. doi:10.1519/jsc.0000000000000819

Andreato, L. V., Lara, F. J. D., Andrade, A., & Branco, B. H. M. (2017). Physical and physiological profiles of Brazilian jiu-jitsu athletes: a systematic review. *Sports Med Open, 3*(1), 9. doi:10.1186/s40798-016-0069-5

Borg, G. A. (1982). Psychophysical bases of perceived exertion. *Med Sci Sports Exerc, 14*(5), 377-381.

Borges, C. C., De Oliveira, R. A., Silva, R. F. S., & Perfeito, P. J. C. (2012). Respostas fisiológicas agudas na prática do jiu-jitsu e correlação com a capacidade aeróbia. *Fiep Bulletin, 82*.

Boutcher, Y. N., & Boutcher, S. H. (2017). Exercise intensity and hypertension: what's new? *J Hum Hypertens, 31*(3), 157-164. doi:10.1038/jhh.2016.62

Carpio-Rivera, E., Moncada-Jimenez, J., Salazar-Rojas, W., & Solera-Herrera, A. (2016). Acute effects of exercise on blood pressure: a meta-analytic investigation. *Arq Bras Cardiol, 106*(5), 422-433. doi:10.5935/abc.20160064

Domingos, E., & Polito, M. D. (2018). Blood pressure response between resistance exercise with and without blood flow restriction: A systematic review and meta-analysis. *Life Sci, 209*, 122-131. doi:10.1016/j.lfs.2018.08.006

Forouzanfar, M. H., Liu, P., Roth, G. A., Ng, M., Biryukov, S., Marczak, L., . . . Murray, C. J. (2017). Global burden of hypertension and systolic blood pressure of at least 110 to 115 mm Hg, 1990-2015. *Jama, 317*(2), 165-182. doi:10.1001/jama.2016.19043

Hecksteden, A., Grutters, T., & Meyer, T. (2013). Association between postexercise hypotension and long-term training-induced blood pressure reduction: a pilot study. *Clin J Sport Med, 23*(1), 58-63. doi:10.1097/JSM.0b013e31825b6974

Keese, F., Farinatti, P., Pescatello, L., & Monteiro, W. (2011). A comparison of the immediate effects of resistance, aerobic, and concurrent exercise on postexercise hypotension. *J Strength Cond Res, 25*(5), 1429-1436. doi:10.1519/JSC.0b013e3181d6d968

Liu, S., Goodman, J., Nolan, R., Lacombe, S., & Thomas, S. G. (2012). Blood pressure responses to acute and chronic exercise are related in prehypertension. *Med Sci Sports Exerc, 44*(9), 1644-1652. doi:10.1249/MSS.0b013e31825408fb

Munakata, M. (2018). Clinical significance of stress-related increase in blood pressure: current evidence in office and out-of-office settings. *Hypertens Res, 41*(8), 553-569. doi:10.1038/s41440-018-0053-1

Pescatello, L. S., Franklin, B. A., Fagard, R., Farquhar, W. B., Kelley, G. A., & Ray, C. A. (2004). American College of Sports Medicine position stand. Exercise and hypertension. *Med Sci Sports Exerc, 36*, 533-553. doi:10.1249/01.MSS.0000115224.88514.3A

Pescatello, L. S., MacDonald, H. V., Lamberti, L., & Johnson, B. T. (2015). Exercise for hypertension: a prescription update integrating existing recommendations with emerging research. *Curr Hypertens Rep, 17*(11), 87. doi:10.1007/s11906-015-0600-y

Petrisor, B. A., Del Fabbro, G., Madden, K., Khan, M., Joslin, J., & Bhandari, M. (2019). Injury in Brazilian jiu-jitsu training. *Sports Health, 11*(5), 432-439. doi:10.1177/1941738119849112

Piskorska, E., Mieszkowski, J., Kochanowicz, A., Wędrowska, E., Niespodziński, B., & Borkowska, A. (2016). Mental skills in combat sports - review of methods anxiety evaluation. *Archives of Budo, 12*.

Prado, É. J., & Lopes, M. C. d. A. (2009). Resposta aguda da frequência cardíaca e da pressão arterial em esportes de luta (jiu-jítsu). *Revista Brasileira de Ciências da Saúde, 7*(22), 63-67. doi:10.13037/rbcs.vol7n22.523

Ruiz, R. J., Simao, R., Saccomani, M. G., Casonatto, J., Alexander, J. L., Rhea, M., & Polito, M. D. (2011). Isolated and combined effects of aerobic and strength exercise on post-exercise blood pressure and cardiac vagal reactivation in normotensive men. *J Strength Cond Res, 25*(3), 640-645. doi:10.1519/JSC.0b013e3181c1fcc7

Scoggin, J. F., 3rd, Brusovanik, G., Izuka, B. H., Zandee van Rilland, E., Geling, O., & Tokumura, S. (2014). Assessment of injuries during Brazilian jiu-jitsu competition. *Orthop J Sports Med, 2*(2), 2325967114522184. doi:10.1177/2325967114522184

Simão, R., Deus, J., Miranda, F., Lemos, A., Baptista, L. A., & Novaes, J. (2007). Hypotensive effects in hypertenses after judo class. *Fitness & Performance Journal, 6*(2). doi:10.3900/fpj.6.2.116.p

Slimani, M., Davis, P., Franchini, E., & Moalla, W. (2017). Rating of perceived exertion for quantification of training and combat loads during combat sport-specific activities: a short review. *J Strength Cond Res, 31*(10), 2889-2902. doi:10.1519/jsc.0000000000002047

Spano, M., Risucci, D. A., Etienne, M., & Petersen, K. H. (2019). Epidemiology of sports related concussion in Brazilian jiu-jitsu: a cross-sectional study. *Sports, 7*(2), 53.

Whelton, P. K., Carey, R. M., Aronow, W. S., Casey, D. E., Collins, K. J., Dennison Himmelfarb, C., . . . Wright, J. T. (2017). 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults. *Journal of the American College of Cardiology*, 24430. doi:10.1016/j.jacc.2017.11.006

Williams, B., Mancia, G., Spiering, W., Agabiti Rosei, E., Azizi, M., Burnier, M., . . . Desormais, I. (2018). 2018 ESC/ESH Guidelines for the management of arterial hypertension. *Eur Heart J, 39*(33), 3021-3104. doi:10.1093/eurheartj/ehy339

Zhou, B., Bentham, J., Di Cesare, M., Bixby, H., Danaei, G., Cowan, M. J., . . . Zuñiga Cisneros, J. (2017). Worldwide trends in blood pressure from 1975 to 2015: a pooled analysis of 1479 population-based measurement studies with 19.1 million participants. *The Lancet, 389*(10064), 37-55. doi:10.1016/S0140-6736(16)31919-5

Øvretveit, K. (2018a). Acute physiological and perceptual responses to Brazilian jiu-jitsu sparring: the role of maximal oxygen uptake. *Int J Perf Anal Spor, 18*, 481-494. doi:10.1080/24748668.2018.1493634

Øvretveit, K. (2018b). Anthropometric and physiological characteristics of Brazilian jiu-jitsu athletes. *J Strength Cond Res, 32*, 997-1004. doi:10.1519/JSC.0000000000002471

Øvretveit, K. (2019). Aerobic interval training improves maximal oxygen uptake and reduces body fat in grapplers. *J Sport Med Phys Fit*. doi:10.23736/S0022-4707.19.09584-7

DOI 10.26773/smj.210211

ORIGINAL SCIENTIFIC PAPER

Methodological Support for the Activities of the Sports Coach

Olga Igorevna Vaganova[1], Maxim Mikhaylovich Kutepov[1], Elena Alexandrovna Chelnokova[1], Anna Vladimirovna Lapshova[1] and Ekaterina Viktorovna Vezetiu[2]

[1]Kozma Minin Nizhny Novgorod State Pedagogical University, Nizhny Novgorod, Russia, [2]V.I. Vernadsky Crimean Federal University, Republic of Crimea, Simferopol, Russia

Abstract

The purpose of this article is to justify and develop the content and structure of an additional course of bachelors in physical education entitled "Methodological support for the activities of a sports coach", to expand the range of their professional competencies. The course involves the disclosure of the theoretical foundations and the practical implementation of the competencies mastered by bachelor students in the context of the new Federal State Educational Standard. The target audience of the course includes bachelor students in physical education, trainers of various categories, teachers in fitness centres, physical education leaders of schools, camps and other persons whose activities are related to the implementation of physical training. In the learning process, information, design, and interactive technologies are used.

We have developed the content of the course for additional training of bachelor students in physical education. The study was carried out for three years (2017–2019). The total number of students in 2017 was 16; by 2018 the number increased to 27, and in 2019 the number grew to 36. This paper presents a study to identify the quantitative and qualitative composition of students attending an additional training course (senior, middle, and junior groups), which enabled determining the relevance of the course content that we have developed. From year to year, the course content has been improved. Statistical data processing revealed a growing number of students from 2017 to 2019. The course is in demand in each of the age categories that we have identified. The results of the study allowed us to identify the direction for further improving the design of the course content, the choice of technologies, methods and tools, which improves the quality of its implementation and, as a result, the quality of its implementation of the methodological activities of physical education specialists.

Keywords: *physical education, competencies, professional and pedagogical activities, higher educational institution, additional training courses*

Introduction

Current activities for the implementation of physical education require appropriate methodological support (H.V. Ihnatenko & K.V. Ihnatenko, 2018). In this article, we consider the preparation of bachelor students in physical education, as well as the development of scientific and methodological support for the activities of physical education trainers (Pogosova, & Tinikashvili, 2019). The content of the preparation of bachelor students in physical education is aimed at studying and improving their physical, mental and functional capabilities (Buzoev, 2019), the practical implementation of the principles of an active and healthy lifestyle with the help of physical culture and sports (Abramova, Vaganova, & Kutepova, 2018). The structure of the undergraduate programme is presented in several blocks (Rakhimbaeva et al., 2019), which include a cycle of professional disciplines, practice, and state final

Correspondence:

O. I. Vaganova
Kozma Minin Nizhny Novgorod State Pedagogical University, Nizhny Novgorod, Russia
E-mail: vaganova_o@rambler.ru

certification (Bulaeva, Vaganova, & Gladkova, 2018). While training at university, a student masters the general characteristics of sporting events (Tomaev, Hosiyev, & Khubetsov, 2019), the features of mass physical-sports events, sports theory, and similar (A.N. Chirva, & O.G. Chirva, 2018). The disciplines they learn are directly related to physical education (Cirdan, 2019). However, in the preparation of a bachelor's degree in physical education, there are not enough disciplines that contribute to the formation of pedagogical competencies (Denysenko, 2018).

Furthermore, since graduates who have mastered the undergraduate programme, according to the requirements of the Federal State Educational Standard, must carry out coaching, recreational, organizational and managerial, research and cultural and educational activities (Bitarova, & Begletsova, 2019), and pedagogical activity (Cheldiev, & Dzaparov, 2019), additional training courses are needed (Garnevska, 2018). To this end, we developed the content of the course for additional training of bachelors in physical education entitled "Methodological support for the activities of the sports coach".

This course is designed to develop additional competencies of students and improve the quality of their work. The content of the course was developed on a modular basis, which allows structuring the material for the best mastery for the audience. According to many scientists, the module represents a certain amount of educational information (Prokhorova, & Semchenko, 2018), which is necessary for the process of implementing professional activities (Pliushch, 2018). Each module is a relatively independent part of the course, performing a specific function (Vaskovskaya, 2018).

As a result of mastering the course, students become proficient in modern scientifically based teaching methods and technologies that are appropriate for the tasks set, as well as organizational methods for working with students; they develop the ability to analyse the technique of motor actions, identify and eliminate the causes of errors with the help of modern teaching methods. Students learn current educational technologies for the implementation of high-quality pedagogical activity, the latest technologies of sports and fitness, sports activities, as well as the methods of playing specific sports (basketball, volleyball, hockey, football, etc.).

The methodological support of the activities of trainers involved in the preparation and implementation of team games is a process that includes the development of training programmes, the planning of specific classes and the solution of common problems regarding the implementation of coaching activities in the implementation of team games.

The features of team game participants are active strategic thinking, active interaction in the game process, replaceability of team members, high psychological stability, endurance and coordination of actions. To create a competitive team and the effective organization of the game, competencies related to the implementation of the methodological support of sports activities are required.

Students of the course include bachelor students in physical education and graduates of higher educational institutions. Participants in the additional training course have the necessary competencies in the field of physical education; however, their professional activity is associated with teaching, so there is a need for additional competencies. Additional training courses contribute to the formation of competence: the ability to develop long-term, operational plans and programmes for specific classes in the fields of youth and mass sports, which requires the use of innovative technologies (Koshechko, 2018). That is, modern specialists need to master additional competence: the ability to design and apply individualized activity- and personality-oriented technologies and teaching methods that are included in the course content (Kobernyk, Stetsenko, Boichenko, & Pryshchepa, 2018) and which students will be able to master after its completion (Nikishina, & Kesareva, 2017).

The purpose of this article is to justify and develop the content and structure of an additional course of bachelors in physical education entitled "Methodological support for the activities of a sports coach", to expand the range of their professional competencies.

Methods

We have developed the content of the course for additional training of bachelor students in physical education. The study was carried out for three years (2017–2019). The total number of students in 2017 was 16; by 2018 the number increased to 27, and in 2019 the number grew to 36.

The content of the course is presented by modules: theoretical and methodological, including legal and organizational and methodological blocks, as well as psychological, pedagogical and control and evaluation blocks; a practice-oriented module includes design work.

The course involves the implementation and study by students of health-promoting technologies, project-based learning technologies, information and interactive technologies, which yield the most significant result in the implementation of professional activities of bachelor students in physical education (Petrichev, Masyuk, & Bushueva, 2018).

Attention was paid to the issue of students' motor activity (Osadchenko, 2019), the features of working with people with disabilities based on the implementation of innovative educational technologies, the study of relevant documentation for professional activities, as well as the use of information, interactive and design technologies in preparation for sports games.

The study involved participants in additional training in physical education at the age of 20 to 37 years. We have identified three groups of students: the youngest age group (20–25 years), the middle group (26–31 years old), and the older age group (32-37 years old). Using statistical data processing, we established the age and number of students attending additional training courses in physical education, conducted a final reflection of the course, which included several questions that made it possible to establish students' satisfaction with the additional training courses in physical education "Methodological support for the activities of a game sports coach".

The demand for the course since the beginning of its implementation has increased significantly; the age composition has also changed. Younger groups have increased interest in a more in-depth study of the material and the improvement of competence for professional activities.

The regulatory framework for the development of the training course was the Federal Law "On Education in the Russian Federation" dated December 29, 2012, with amendments and additions to 2020; Federal Law "On Physical Culture and Sport in the Russian Federation"; "The strategy for the development of physical education and sports in the Russian Federation for the period until 2020."

The course material is structured according to the module principle, according to which each section of the programme is represented by a coherent, logically complete module.

In the process of developing the legal and theoretical and methodological blocks of the course, the students studied the materials on the legal documentation, the requirements for preparing students, the basics of sports training, planning in the field of physical education and sports, the organization of physical culture management, the implementation of health-promoting technologies in preparing students, the basics health-improving physical culture, conducting classes for people with disabilities using information technology, warning of injury if many exercises by implementing the health-promoting technologies. The psychological and pedagogical unit includes the study of students' motivation for physical education (Raven, 2017), and the features of interaction with students with disabilities (Koroeva, & Vorobyova, 2019). During the implementation of the practice-oriented module, students performed creative design work, which prepares students for competitions using innovative educational technologies.

The content of the course reveals the use of educational technologies in preparing a coach for the implementation of game sports, taking into account the characteristics of sports games (basketball, volleyball, hockey, etc.). Since each sport requires high basic indicators (the level of endurance (Nikonova, Vaganova, Smirnova, Chelnokova, & Kutepov, 2019b), speed-strength qualities, technical and tactical skills, a stable psyche, sociability in a team), each coach should provide appropriate training (Oros, 2018). The course participants plan training sessions in accordance with the gender and age characteristics of students' development (Markova, & Narcosiev, 2018), functional groups, individual characteristics of health restrictions based on the implementation of health-promoting technologies (Nikonova, Vaganova, Smimova, Bystrova, & Markova, 2019a). The course forms in students the skill of creating a steady student interest.

Results

The results of statistical processing of data on the quantitative and age composition of students attending the course "Methodological support for the activities of a sports trainer" showed that most students are represented by the older age group (32–37 years old; Figure 1).

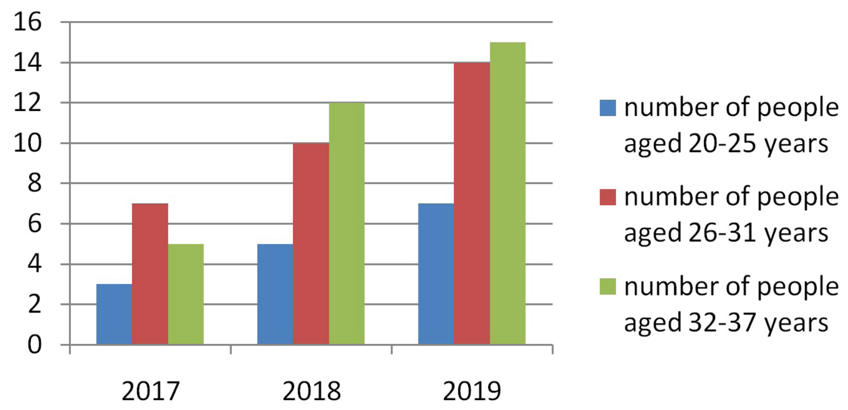


FIGURE 1. The composition of the students of the course of additional training in physical education "Methodological support of the activities of the sports coach"

These indicators are explained by the need of older people to update and expand their knowledge, and the formation of additional competencies. Younger (20–25 years old) and middle (26–31 years old) age groups only receive vocational education and do not show much interest in participating in courses. However, we can observe that by 2019 the number of young and middle-aged students had increased. They showed interest in a more in-depth study of the material.

From year to year, there has been an increase in the total number of students. A the time of the opening of the course in 2017, this number was 16; by 2018, it had increased to 27, and in 2019 the number attending the courses grew to 36 (Figure 1).

In Figure 2, we present the increase in the number of course participants as a percentage.

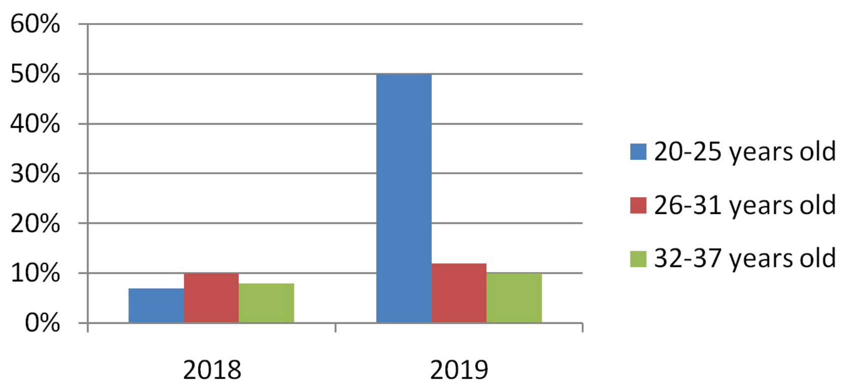


FIGURE 2. The results of the statistical processing of data on the number of students attending courses of additional training in physical education "Methodological support of the activities of the trainer of game sports" in a percentage ratio (compared to 2017)

We can observe that by 2019 (compared with the beginning of the implementation of the courses), the number of students making up the younger age group increased by 50%.

We also checked the satisfaction of students with courses of additional training in physical education in 2019. To do so, a survey was conducted, with a wide list of questions regarding the assessment of students' activities and the implementation of additional training courses in general. Table 1 shows a fragment of a survey of participants in an additional training course.

Table 1. The results of the statistical processing of the survey data to identify satisfaction with additional training courses for bachelors in physical education

No.	Questions	Answers (%)
1	Do you think that additional training in the course contributes to improving the competence and the formation of additional competencies?	Yes - 80% More likely than not - 20% More likely no than yes - 0% No - 0%
2	What do you consider the most valuable in the course?	- development of skills to work with regulatory documents for the implementation of professional activities - 40% ; - development of the skill of implementing innovative technologies in professional activities - 85% - mastering additional competencies to improve the quality of physical education teaching - 92%
3	What technologies implemented in the course contributed most to the preparation of the final project?	- health-promotion - 70 % - information - 89%; - interactive - 69%; - project training - 91%

The results of the statistical processing of the survey data allowed us to establish that the vast majority of students attending a course of additional training for bachelors in physical education are satisfied with the results. The content of the course provides ample opportunities for more in-depth development of the material, improving competence. Interest is determined by the need to improve professional competence using modern, specialized tools and programmes for subsequent training sessions; the need for professional and educational growth, writing scientific publications on the issues of training activities, studying the experience of implementing training activities.

Discussion

Physical education issues are considered in the works of various authors: Turaboev and Sultonov (2020), Garmaev and Dugarova (2015) and others. However, additional training for bachelors requires additional attention.

We developed the content and structure of the course of additional training of bachelors in physical education "Methodological support of the activities of the sports coach", expanding the range of professional competencies. The course contributes to the formation of competence: the ability to design and apply individualized, activity- and personality-oriented technologies and teaching methods.

Our study allowed us to establish an increase in the number of students from the introduction of courses in 2017 to 2019, which occurred in all groups identified by us (the youngest age group (20–25 years old), the average age group (26–31 years old), older age group (32–37 years old); the largest growth is observed among students of the younger age group (at 50%), which suggests that the courses developed and implemented by us motivate students to study materials more deeply and improve their competence to carry out professional activities at a higher level. According to the purposes of the courses, students acquire additional competence that expands the possibilities for the implementation of physical education classes. We also checked the satisfaction of students with the additional training course for bachelors in physical education "Methodological support for the activities of a sports coach" in 2019.

Acknowledgements
There are no acknowledgments

Conflict of Interest
The authors declare that there are no conflicts of interest.

Received: 04 April 2020 | **Accepted:** 07 June 2020 | **Published:** 01 February 2021

References

Abramova, N. S., Vaganova, O. I., & Kutepova, L. I. (2018) Development of educational and methodological support in the context of the implementation of content and communication technologies. *Baltiyskiy gumanitarnyy zhurnal (Baltic Humanitarian Journal), 7*, *2*(23), 181-184.

Bulaeva, M. N., Vaganova, O. I., Gladkova, M. N. (2018). Activity technologies in a professional educational institution. *Baltiyskiy gumanitarnyy zhurnal (Baltic Humanitarian Journal), 7*, *3*(24), 167-170.

Bitarova, A. L., & Begletsova, D. V. (2019). Development of mass sport as a basis of healthy lifestyle of civilian population. *Humanitarian Balkan Research*, *3*(5), 5-7.

Buzoev, A. S. (2019). Health strengthening of students by means of physical culture as an important pedagogical problem. *Humanitarian Balkan Research*, *3*(5), 8-10.

Chirva, A. N., & Chirva, O. G. (2018). Contents and method of professionally oriented training of informatic courses of future teachers of technologies. *Scientific Vector of the Balkans, 1*, 27-31.

Cheldiev, Z. R., & Dzaparov, V. K. (2019). The development of physical culture and sport is an important social significant task of the state. *Balkan Scientific Review, 3*(5), 12-14.

Cirdan, A. P. (2019). Innovative technologies of professional training of future economists in the system of continuous education. *Humanitarian Balkan Research*, *2*(4), 27-30.

Denysenko, S. M. (2018). Application of quest technology in the professional training Of Bachelor of Publishing and Polygraphy in Higher School. *Balkan Scientific Review, 1*, 29-33.

Garnevska, S. M. (2018). Opportunities for forming communication technology images in training in technology and entrepreneurship. *Balkan Scientific Review, 1*, 34-37.

Garmaev, V. B., & Dugarova, J. V. (2015). Physical training of combatants at the initial stage of training. Bulletin of the Buryat State University. *Education Personality* Society, *2*, 83-86.

Ihnatenko, H. V., & Ihnatenko, K. V. (2018). Development of self-dependence as a professional ly-important personality trait of a future vocational education teacher by means of case-technology. *Humanitarian Balkan*

Research, 1, 40-42.

Koroeva, T. B., & Vorobyova, I. N. (2019).Physical culture as a major factor of students self-development. *Balkan Scientific Review*, *3*(5), 26-28.

Nikishina, A. L., & Kesareva, E. M. (2017). State and prospects of development of personnel exchange in secondary vocational education. *Azimuth of Scientific Researches: Economics and Management, 6, 4*(21), 104-108.

Koshechko, N. V. (2018). Innovations from educational discipline "Pedagogical conflictology" in professional preparation of students. *Scientific Vector of the Balkans, 1*, 59-63.

Kobernyk, O. M., Stetsenko, N. M., Boichenko, V. V., & Pryshchepa, S. M. (2018). Improving professional and pedagogical training of future teachers by moodle platforms (On the example of the course "Pedagogy"). *Scientific Vector of the Balkans*, *1*, 5-7.

Oros, I. I. (2018). The role of international connections in the development of the adult education system. *Humanitarian Balkan Research, 1*, 57-59.

Markova, S. M., & Narcosiev, A. K. (2018). Professional education of vocational school students. *Vestnik Mininskogo universiteta (Vestnik of Minin University), 6*(3), 3. doi: 10.26795/2307-1281-2018-6-3-3.

Nikonova, N. P., Vaganova, O. I., Smimova, Z. V., Bystrova, N. V., & Markova, S. M. (2019a). Providing partnerships and promotion of additional educational services. *International journal of applied exercise physiology, 8*(2.1), 347-355.

Nikonova, N. P., Vaganova, O. I., Smirnova, Z. V., Chelnokova, E. A., & Kutepov, M. M. (2019b). Methodological support in partnerships with the institution of additional education and teachers. *International journal of applied exercise physiology, 8*(2.1), 339-346.

Pichugina, G. A., & Bondarchuk, A. I. (2019). Structure of the training case in the organization of the educational process. *Humanitarian Balkan Research*, *2*(4), 5-7.

Prokhorova, M. P., & Semchenko, A. A. (2018). Involving of trainees-future teachers of professional training in project activities in the discipline. *Vestnik Mininskogo universiteta (*Vestnik of Minin University), *6*(2), 6. doi: 10.26795/2307-1281-2018-6-2-6.

Pogosova, S. N., & Tinikashvili, G. S. (2019). Development of mass sports as a basis for healthy life style of studying youth. *Scientific Vector of the Balkans*, *3*(5), 41-43.

Pliushch, V. M. (2018). Independent work of students as a factor of improving education quality. *Balkan Scientific Review, 1*, 69-71.

Petrichev, P. V., Masyuk, N. N., & Bushueva, M. A. (2018). Method of estimation of the effectiveness of the partnership russian universities with foreign educational organizations, Azimut nauchnykh issledovaniy (*Azimuth of Scientific Researches: Economics and Management), 7, 3*(24), 229-232.

Tomaev, E. K., Hosiyev, F. B., & Khubetsov, A. M. (2019). Modern realities of physical development of the growing generation. *Scientific Vector of the Balkans*, *3*(5), 44-46.

Turaboev, E. Yu., & Sultonov, R. U. (2020). Preparing students for physical activity. *Problems of Science*, *1*(49), 77-78.

Osadchenko, I. I. (2019). Key concepts of situational training technology in preparing future teachers. *Scientific Vector of the Balkans, 1*(3), 46-49.

Raven, J. (2017). Education and Sociocybernetics, Azimut nauchnykh issledovaniy (*Azimuth of Scientific Researches: Economics and Management), 6, 3*(20), 289-297.

Vaskovskaya, G. A. (2018). Features of implementation of pedagogical technologies of profile training. *Balkan Scientific Review, 1*, 76-79.

Rakhimbaeva, I. E., Korostelev, A. A., Shakirova, I. A., Ayshwarya, B., Phong, T. N., Hashim, W., & Maseleno, A. (2019). Integration of the Educational and Didactic Systems in the Training of Future Teachers. *International Journal of Applied Exercise Physiology*, *8*(2.1), 1131-1136.

DOI 10.26773/smj.210212

ORIGINAL SCIENTIFIC PAPER

Cycling as Transportation & COVID-19: Advantages of Shared Bicycles during Epidemics

Vahid Saatchian[1], Amin Azimkhani[2], Mutlu Türkmen[3] and Dorri Dolatkhah Laein[4]

[1]Imam Reza International University, Sports Management Department, Mashhad, Iran, [2]Imam Reza International University, Sports Science Department, Mashhad, Iran, [3]Bayburt University, Physical Education and Sports College, Bayburt, Turkey, [4]Imam Reza International University, Sports Management Department, Mashhad, Iran

Abstract

In addition to the environmental problems that have plagued human life in recent decades, the outbreak of the coronavirus epidemic has endangered people's health and adversely affected their lives in other ways. Therefore, the present study aimed to investigate the advantage of using shared bicycles (SB) during the outbreak of epidemics. For this purpose, 310 male subscribers of an SB system were examined. The research tool was a questionnaire taken from studies. The results showed that the environmental and health advantages were favourable, but the place advantage indicated a relatively unfavourable situation. The results of the structural equation model also showed that the advantages of using an SB based on the highest impact are the motivational advantage, health advantage, environmental advantage, social advantage, financial advantage and place advantage. These results can provide useful solutions for governments to reduce environmental risks and maintain health and physical activity during epidemics.

Keywords: *shared bike, bicycle advantage, epidemics, COVID-19*

Introduction

The world is dealing environmental pollution issues caused by exhaust emissions,including hydrocarbons, nitrogen oxides, carbon monoxide, and particulate matter from vehicles using traditional fuels, such as gasoline and diesel, and these were expected to significantly increase by 2020 (Pielecha, Merkisz, Jasiński, & Gis, 2015). In recent decades, the emphasis of urban transport policies has been placed on developing sustainable transportation strategies in a way that protects the interests of future generations. Civil society organizations are considering sustainable low-carbon transportation options and measures to increase non-motorized transportation modes (such as cycling and walking) (Agarwal, Ziemke, & Nagel, 2019). Today, due to various transportation problems and various environmental pollutants; as an active and sustainable means of transportation, bicycles play an essential role in the development of multilateral transportation systems (Rybarczyk & Wu, 2010). Therefore, doing sports activities in accordance with the principles of health can also improve people's physical and mental health during epidemics.

Physical activity (PA)also plays a significant role in mental health and cognitive function because exercise has positive effects on preventing and reducing depressive symptoms, reducing anxiety, improving learning, and is useful for cognitive function in the elderly.In addition to promoting PA, participation in sports allows the participant to progress psychosocially, become a member of a community, and create a social network. With limited social activities due to mandated restrictions, organized sports activities are greatly reduced during the virus outbreak.In this regard, it is imperative to continue physical activity (PA) in order to maintain good physical and mental health while facing the current challenges imposed by COVID-19 (Jakobsson, Malm, Furberg, Ekelund, & Svensson, 2020). As the world has struggled with COVID-19, sports faced an unprecedented

Correspondence:

A. Azimkhani
Imam Reza International University, Sports Science Department, Razavi Khorasan Province, Mashhad, Sanabaad, Daneshgah Avenue, Iran Mashhad, Iran
Email: amin.azimkhani@imamreza.ac.ir

crisis. Tournaments have been cancelled and postponed, and quarantined athletes lead to adverse decisions about sports activities (Gallego, Nishiura, Sah, &Rodriguez-Morales, 2020).

However, the use of personal transport compared to public transport can have different benefits during epidemics. By providing numerous benefits for traffic, health and cost, cycling has led to rapid growth as an important transportation mode in many countries (Saplıoğlu& Aydın, 2018). Cycling can help reduce pollution and traffic congestion. Bicycles consume less energy and bring health to their users. They can also provide quick, affordable access to parts of cities that are more difficult to reach by public transport or large vehicles (Karanikola, Panagopoulos, Tampakis, & Tsantopoulos, 2018).Cycling is also a good source of PA at a time in which physical activity is declining, and obesity is relatively widespread (Killingsworth, 2003). Cycling is a type of physical activity that offers multiple benefits to its users. In addition to satisfaction (De Hartog, Boogaard, Nijland, & Hoek, 2010), cycling provides significant flexibility over other modes of transportation (Akar & Clifton, 2009) while simultaneously makingtravel affordable, thereby increasing social cohesion (Gatersleben & Appleton, 2007). Bicycles are also beneficial for health and longevity (Reynolds, Winters, Ries, & Gouge, 2010), and have significant health effects, especially for groups with low or moderate levels of exercise (Börjesson & Eliasson, 2012).

Pucher and Boehler's (2008) study showed that cities with high levels of cycling and adequate safety tend to have extensive infrastructure as well as pro-cycling policies and programs. The research of Que & He (2018) suggests thatSB can play an essential role in the development of urban transportation and provide useful information for urban transportation policies. Also, Legros (2019) shows that only a small amount of intervention from the operator, such as changing the location of the bikes, prioritizing the nearest and most active stations, can significantly increase the quality of bicycle services.Dill (2009) has also demonstrated that cycling can be used for transportation by adults to follow the recommendations for daily PA.De Hartog et al. (2010) indicate that due to the health benefits of increasing PA, there are significant social benefits for cycling. The findings of R. Wu, Z. Wu, Wen, Cai, and Li (2019) show that in the relationship between perceived usefulness and usage intention, perceived ease of use and facilitating conditions played moderating roles. However, concerning the effect of enjoyment on usage intention, the moderating effects of perceived ease of use and facilitating conditions were not significant. Handy and Xing (2011) provide empirical evidence of the impact of physical and social environmental factors on cycling, although individual attitudes and limitations are the most critical determinants of cycling.Akar & Clifton (2009) have stated that people who consider walking and cycling to bea form of exercise and identify flexibility of departure time as an essential factor in their mode choice are more likely to use bicycles.

Maintaining regular PA during self-isolation (quarantine) due to a sedentary lifestyle is essential in preventing chronic health conditions in the future. During crises, applied medical care and community service are of paramount importance.To prevent physical and mental distress, governments, public health officials, and the public themselves need to be vigilant in maintaining PA during the COVID-19 pandemic (Jakobsson et al., 2020).Physical inactivity is a growing problem that exists both individually and socially. The World Health Organization (WHO) has concluded that physical inactivity and overweight/obesity are the fourth and fifth most dangerous risk factors for non-communicable diseases, respectively (Raustorp & Koglin, 2019).Sports activities that bring communities together are also intricately linked to particularly significanthuman health problems (Memish et al., 2019). In the current pandemic, in which the infection increasingly global and interdependent in almost every corner of the globe and has the potential to transcend psychological and economic boundaries, many important sporting events have either been cancelled or postponed to a definite or uncertain future date (Gilat &Cole, 2020; Brown & Horton, 2020).The severity of the situation could also lead to austerity measures by governments in various countries to prevent the spread of the disease (Corsini, Bisciotti, Eirale, & Volpi, 2020).

Concerned about changing world conditions, cities around the world have begun to implement policies to promote cycling (Karanikola et al., 2018). In this regard, the emergence of bike-sharing is closely related to its social and environmental benefits (Qiu & He, 2018) and is a good option for solving environmental problems related to the use of automobiles in major European cities (Zuurbier, Willems, Schaap, Van der Zee, & Hoek, 2019). These bikes can reduce the emission of hazardous particles and gaseous pollutants (MacNaughton, Melly, Vallarino, Adamkiewicz, & Spengler, 2014), and also reduce traffic congestion (Legros, 2019) and reduce noise pollution (Caulfield, O'Mahony, Brazil, & Weldon, 2017).Therefore, the present study seeks to provide valuable results in this regard by examining the benefits of using SB services in comparison with public transport (bus and taxi) during the outbreak of epidemic diseases. Thus, it is imperative to conduct this study in terms of the conditions under review and the current environment in countries affected by coronavirus epidemic, especially in Iran, which has been one of the high-risk countries for this epidemic. However, only limited research has directly or indirectly investigated SB and epidemics.

Methods

Participants

The statistical population of the study included all male registrants in the SB system of the city of Mashhad who regularly used SB (N=310). According to the statistical population type, the sample size was calculated to be 170 using the Morgan table. Table 1 shows the general characteristics of the Participants.

Research tool

To measure the behaviour of SB users, a questionnaire containing 24 questions was used, which was classified into five components: environmental advantage, financial advantage, place advantage, health advantage, social advantage, and motivational advantage. This tool has been adapted from previous research studies (Huang, 1998; Lim, 2006) on the use of shared bicycles. The main components and contents of the questionnaire are given in Table 2.

The questionnaire was measured on a five-point Likert scale.

Table 1. Demographic Details of the Participants

Characteristic		Frequency	Percentage
Age	-20	2	1.2
	21-30	44	25.9
	31-40	51	30
	+41	73	42.9
Marital status	Single	33	19.4
	Married	137	80.6
Education	Diploma & less	37	21.8
	College degree	38	22.4
	Bachelor	72	42.4
	Master & more	23	13.5
job	Self-employment	50	29.4
	Employee	76	44.7
	Student	15	8.8
	Retired	29	17.1

Table 2. Questionnaire Configuration

Factor	Item	Number of Items
Environmental advantage	Bicycle usefulness for environment	4
	Energy efficiency	
	Environmentally friendly production process	
	Less environmental pollution	
Social advantage	Correct Informing	5
	Attract specific contacts	
	Increase environment awareness	
	Enough city advertising	
	Creating environmental attitude	
Financial advantage	Fair cost	3
	Good money value	
	Save time and money	
Place advantage	Appropriate station distances installation	4
	Stations access in residential areas	
	Stations' suitable number	
	Proper station schedule	
Health advantage	Reducing stress	4
	Relaxation	
	health and fitness	
	Keep fitness	
Motivational advantage	Belonging to SB system	4
	Commitment to SB system	
	Continuous use of SB	
	Introducing the SB to others	

Validity test

A factor analysis was conducted to guarantee the validity, and as shown in Table 3, the questionnaire about the use of SB includes five factors: environmental advantage, financial advantage, place advantage, health advantage, social advantage, and motivational advantage. Factors accounted for about 62% of the total variance, and the reliability coefficient of the questionnaire was all over 0.8 ($\alpha = 0.820$) in total, thus proving reliability.

Data processing

After the inappropriate data were deleted, the collected data were subjected to extensive analysis and performance anal-

Table 3. Factor Analysis of advantages of shared bike

Item		Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Motivational advantage	BBS	0.643					
	CBS	0.526					
	CUB	0.645					
	IBO	0.580					
Place advantage	ASDI		0.505				
	SARA		0.642				
	SSN		0.589				
	PSS		0.362				
Social advantage	CI			0.791			
	ASP			0.617			
	IEA			0.621			
	ECA			0.761			
	CEA			0.551			
Financial advantage	FC				0.845		
	GMV				0.851		
	STM				0.682		
Environmental advantage	BUE					0.784	
	EE					0.613	
	FEPP					0.608	
	LEP					0.706	
Health advantage	RS						0.874
	R						0.838
	HF						0.372
	KF						0.458
Eigenvalue		3.146	2.736	2.576	2.248	2.100	2.027
% of Variance		13.108	11.399	10.732	9.365	8.750	8.444
Cumulative %		13.108	24.506	35.238	44.603	53.354	61.798
Cronbach's α		0.749	0.802	0.750	0.780	0.641	0.769

Legend: BBS-Belonging to SB system; CBS-Commitment to SB system; CUB-Continuous use of shared bike; IBO-Introducing the SB to others; ASDI-Appropriate station distances installation; SARA-Stations access in residential areas; SSN-Stations' suitable number; PSS-Proper station schedule; CI-Correct Informing; ASP-Attract specific contacts; IEA-Increase environment awareness; ECA-Enough city's advertising; CEA-Creating environmental attitude; FC-Fair cost; GMV-Good money value; STM-Save time and money; BUE-Bicycle usefulness for environment; EE-Energy efficiency; FEPP-Friendly environmentally production process; LEP-Less environmental pollution; RS-Reducing stress; R-Relaxation; HF-health and fitness; KF-Keep fitness

ysis of the importance of the components. First, a frequency analysis was conductedto examine the demographic characteristics of the subjects. Then, exploratory factor analysis was conducted to validate the components of the advantage of using a shared bike, including the environmental, financial, place, social, health, and motivational advantages.Data reliability was also confirmed by Cronbach's alpha coefficient, which measures internal consistency between the items.

Finally, performance analysis of item importance was performed based on SB users, using SPSS 24. Also, the structural equation model of the relationship between cycling and its components is illustrated using AMOS software in Figure 1. The output results of the structural equation model are shown in Tables 4 and 5.

Table 4. Output results of the structural equation model

Variable		Variable	Estimate	S.E.	C.R.	P	Standard regression weight
Environment advantage	<---	Cycling	1.000				0.516
Financial advantage	<---	Cycling	2.028	0.751	2.702	0.007	0.378
Motivation advantage	<---	Cycling	3.719	1.133	3.281	0.001	0.785
Place advantage	<---	Cycling	2.212	0.922	2.399	0.016	0.307
Social advantage	<---	Cycling	3.638	1.189	3.060	0.002	0.517
Health advantage	<---	Cycling	3.192	0.986	3.238	0.001	0.579

Table 5. Model fit indicators

Fit indicators	CMIN/DF	P	GFI	IFI	CFI	RMSEA
Amount	1.996	0.0001	0.814	0.819	0.815	0.077

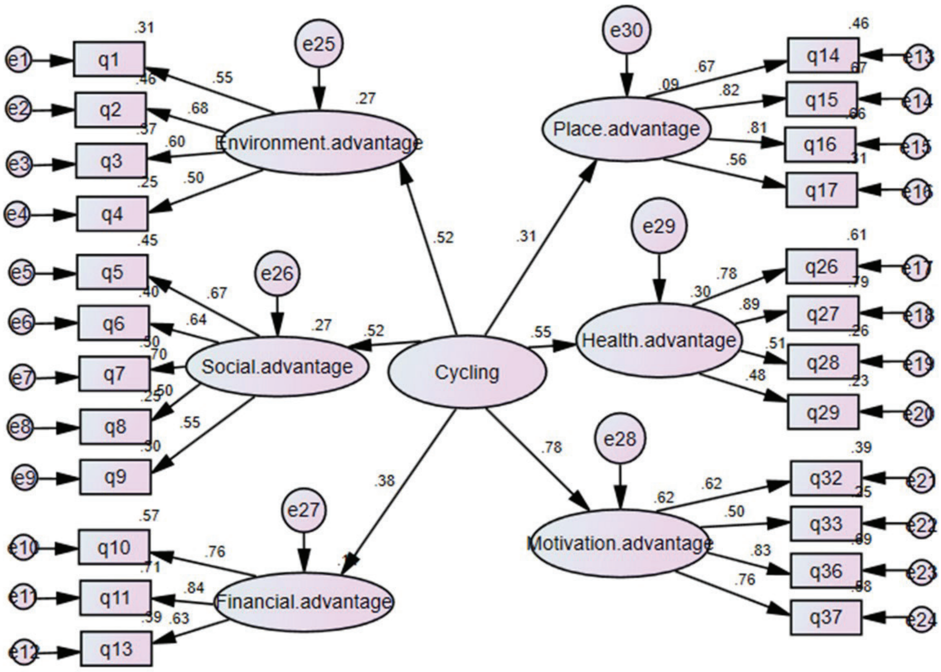


FIGURE 1. Structural Equation Model

Results

One-sample t-test was used to investigate the role and importance of research components. The output results are shown in Tables 6.

Table 6. One-sample statistics

Variable	Mean±Std. Dev.	Std. Error Mean
Environment advantage	4.68±0.369	0.028
Social advantage	3.20±0.720	0.055
Financial advantage	4.26±0.596	0.045
Place advantage	2.90±0.922	0.070
Health advantage	4.27±0.524	0.040
Motivation advantage	4.18±0.595	0.045

The average score of the environmental advantages item (4.68) indicates a favourable situation, in which the usefulness of the SB for the environment and the lower environmental pollution have a higher average. Also, the average score of the health advantages item (4.27) indicates the favourable situation that health and well-being and maintaining the fit of the bicycle have a higher average. The average score of the financial advantages item (4.26) also indicates the favourable situation that the fair cost of using anSB has a higher average. The average score of the motivational advantages item (4.18) indicates a favourable situation, which means that the continuation of using SB and the introduction of the SBsystem to others have a higher average. The average score of the social advantages item (3.20) indicates a relatively favourable situation, which is a higher average than the increase in awareness of the environment and the creation of an ecological environment. However, the average score of the place advantages item (2.90) indicates the relatively unfavourable situation in which the appropriate number of stations and the appropriate schedule of the stations have the lowest average. Also, according to the coefficients of the path explained in the structural equation model, the motivational advantage (0.78), health advantage (0.55), environmental advantage (0.52), social advantage (0.52), and financial advantage (0.38) and spatial advantage (0.62) have the highest impact.

Discussion

In general, assessing the outbreak of COVID-19 throughout the world requires a comprehensive and systematic understanding. In addition, the focus of the effects of this crisis on countries'sports industry sports services, especially people's physical activities. Therefore, one of the topics that can be examined in this period is to perform healthy activities with respect to social distance, because of the use of shared bicycles is considered as a suitable temporary solution. Therefore, one of the topics that can be examined in this period is to perform healthy activities regard to social distance, which because of the use of SB is considered as a suitable temporary solution.

However, attention to the issue of home quarantine has always been a complex challenge for politicians. As a result, the present study seeks to identify the advantages of using anSB. According to the research findings, the advantages of cycling are of great importance, and each has significant effects on its own. This finding is consistent with those of Mueller et al. (2015), Gatersleben and Appletonet (2007), Saplıoğluand Aydın (2018), Karanikola et al. (2018). Willis, Manaugh, and El-Geneidy (2015) state that these factors, especially understanding the advantages of cycling, reflect the attitude towards cycling and other modes of transportation. The following are an analysis of each of the advantages of the shared bike:

Motivational advantage

The importance and high impact of motivational advantage reflect the value of SB use among its users. Acommitment to SB systems leads to the continued use of shared bikes. Users of these systems are extremely interested in introducing SB to other citizens for transportation in the city. Analysing the research of Handy and Jing (2011) reveals that individual attitudes and limitations are the most critical determinants of cycling. This can be considered the most critical factor for users of this device compared to public transportation during the outbreak of COVID-19. As a result, paying attention to the motivational needs of users against the use of this device is one of the essential priorities of decision-makers.

Health advantage

The importance and impact of health benefits reflect the high value of SB use among its users. Cycling can meet the health expectations of its users. The use of SB is effective in improving the health and well-being of citizens and aids in relaxing and reducing stress, especially during the COVID-19 outbreak, while also helping them to maintain fitness and improve their physical fitness during quarantine. Mueller et al. (2015) stated that the effect of increasing physical activity had the highest estimate on the health advantages, which far exceeded the harmful effects of traffic accidents and air pollution on health. Therefore, paying attention to this aspect of advantage compared to public transportation during the outbreak of COVID-19 can improve the immune system of users, in addition to aiding in controlling the widespread outbreak of this disease.

Environmental advantage

The importance and impact of environmental advantages also show the high value of SB use among its users. Cycling, as a means of transportation, seems to be useful for the environment compared to the public transportation; it is very efficient in terms of energy consumption and can minimize environmental pollution through anenvironmentally friendly production process. In their research, Qiu and He (2018) showed that bicycle sharing significantly reduced traffic, reduced energy consumption, reduced emissions, and overall environmental protection. Because the use of public transportation causes environmental pollution and is a significant factor in the spread of the disease, to the use of SB is a crucial factor in this issue.

Social advantage

The relatively moderate importance and impact of social advantage suggest that by informing and raising awareness about the environment, as well as safe transportation methods during the outbreak of epidemics, more users can be encouraged to use SB. Attracting specific audiences and creating environmental and personal health attitudes in them can lead to an increase in SB users. Handy and Xing (2011) stated that the social environment and the development of bicycle use policies and programs are effective in increasing the rate of cycling. However, during this period, social constraints have made this issue of moderate importance.

Financial advantage

The importance and impact of financial advantages reflect the value of using anSB to its users. The fair cost of using SB and the association of good value for money is vital for general bike users. Cycling also saves time and money, which is valuable for users. In this regard, Börjesson andEliasson (2012) stated that with the development of bicycles and increasing their speed and comfort, the use of bicycles for users will be affordable. As a result, the development of bicycle-based networks in the city can provide better support to users during the outbreak of epidemics.

Place advantage

The low importance and impact of place advantages suggest that creating and deploying the right number of bike stations in residential areas and easy access to them, as well as creating the right schedule for stations, increases the number of SB users during the outbreak of epidemics. Branion, et al. (2019) state that the greater availability of bicycle infrastructure, especially SB stations and bicycle lanes, is associated with a greater chance for cycling in the city. As a result, it is suggested that while developing available places for users, attention should be paid to maintaining control over the outbreak of epidemics to use public transportation.

Maintaining regular PA during self-isolation (quarantine) is essential for preventing future chronic health conditions due to sedentary lifestyles. In times of crisis, functional medical care and community service are of the highest priority.To prevent physical and mental distress, governments, public health officials, and the public itself should also care for maintaining PA during the COVID-19 epidemics (Jakobsson et al., 2020). Therefore, targeted studies on community transportation can improve health and thus increase life expectancy during the epidemic.

Acknowledgements
There are no acknowledgments

Conflict of Interest
The authors declare that there are no conflicts of interest.

Received: 14 June 2020 | **Accepted:** 03 August 2020 | **Published:** 01 February 2021

Reference

Akar, G., & Clifton, K. J. (2009). Influence of individual perceptions and bicycle infrastructure on decision to bike. *Transportation research record, 2140*(1), 165-172.
Agarwal, A., Ziemke, D., & Nagel, K. (2019). Bicycle superhighway: An environmentally sustainable policy for urban transport.*Transportation Research Part A: Policy and Practice*, *137*, 519-540.
Börjesson, M., & Eliasson, J. (2012). The value of time and external benefits in bicycle appraisal. *Transportation Research Part A: Policy and Practice, 46*(4), 673-683.
Brown, A., & ve Horton, R. (2020). A planetary health perspective on Covıd-19: a call for papers. *The Lancet Planetary Health and the Lancet, 395*, 1099.doi.org/10.1016/s01406736(20)30742-x.
Caulfield, B., O'Mahony, M., Brazil, W., & Weldon, P. (2017). Examining usage patterns of a bike-sharing scheme in a medium sized city. *Transportation*

research part A: policy and practice, 100, 152-161.

Corsini, A., Bisciotti, G. N., Eirale, C., & Volpi, P. (2020). *Football cannot restart soon during the COVID-19 emergency*! A critical perspective from the Italian experience and a call for action.

De Hartog, J. J., Boogaard, H., Nijland, H., & Hoek, G. (2010). Do the health benefits of cycling outweigh the risks. *Environmental health perspectives, 118*(8), 1109-1116.

Dill, J. (2009). Bicycling for transportation and health: the role of infrastructure. *Journal of public health policy, 30*(1), S95-S110.

Gallego, V., Nishiura, H., Sah, R., & Rodriguez-Morales, A. J. (2020). The COVID-19 outbreak and implications for the Tokyo 2020 Summer Olympic Games.*Travel medicine and infectious disease*,*34*, 101604. https://doi.org/10.1016/j.tmaid.2020.101604

Gatersleben, B., & Appleton, K. M. (2007). Contemplating cycling to work: Attitudes and perceptions in different stages of change. *Transportation Research Part A: Policy and Practice, 41*(4), 302-312.

Gilat, R., &Cole, B.J. (2020). Covid-19. Medicine and Sports.*Arthroscopy, Sports Medicine, and Rehabilitation*, *2*(3), 175-176. doi:org/10.1016/j.asmr.2020.04.003.

Handy, S. L., & Xing, Y. (2011). Factors correlated with bicycle commuting: A study in six small US cities. *International Journal of Sustainable Transportation, 5*(2), 91-110.

Jakobsson, J., Malm, C., Furberg, M., Ekelund, U., & Svensson, M. (2020). Physical Activity during the Coronavirus (COVID-19) Pandemic: Prevention of a Decline in Metabolic and Immunological Functions. *Frontiers in Sports and Active Living, 2*, 57.

Karanikola, P., Panagopoulos, T., Tampakis, S., & Tsantopoulos, G. (2018). Cycling as a smart and green mode of transport in small touristic cities. *Sustainability, 10*(1), 268.

Killingsworth, R. E. (2003). Health promoting community design: a new paradigm to promote healthy and active communities. *American Journal of Health Promotion, 17*(3), 169-170.

Legros, B. (2019). Dynamic repositioning strategy in a bike-sharing system; how to prioritize and how to rebalance a bike station. *European Journal of Operational Research, 272*(2), 740-753.

MacNaughton, P., Melly, S., Vallarino, J., Adamkiewicz, G., & Spengler, J. D. (2014). Impact of bicycle route type on exposure to traffic-related air pollution. *Science of the total environment, 490*, 37-43.

Memish, Z. A., Steffen, R., White, P., Dar, O., Azhar, E.I., Sharma, A., &Zumla, A. (2019). Mass gatherings medicine: public health issues arising from mass gathering religious and sporting events. *The Lancet, 393*, 2073–84.

Mueller, N., Rojas-Rueda, D., Cole-Hunter, T., de Nazelle, A., Dons, E., Gerike, R., … & Nieuwenhuijsen, M. (2015). Health impact assessment of active transportation: a systematic review. *Preventive medicine, 76*, 103-114.

Pielecha, J., Merkisz, J., Jasiński, R., & Gis, W. (2015). *Real driving emissions testing of vehicles powered by compressed natural gas (No. 2015-01-2022)*. SAE Technical Paper.

Pucher, J., & Buehler, R. (2008). Making cycling irresistible: lessons from the Netherlands, Denmark and Germany. *Transport reviews, 28*(4), 495-528.

Qiu, L. Y., & He, L. Y. (2018). Bike sharing and the economy, the environment, and health-related externalities. *Sustainability, 10*(4), 1145.

Reynolds, C., Winters, M., Ries, F., & Gouge, B. (2010). Active transportation in urban areas: exploring health benefits and risks. *National Collaboration Centre for Environmental Health, 2*.

Raustorp, J., & Koglin, T. (2019). The potential for active commuting by bicycle and its possible effects on public health. *Journal of Transport & Health, 13*, 72-77.

Rybarczyk, G., & Wu, C. (2010). Bicycle facility planning using GIS and multi-criteria decision analysis.*Applied Geography,30*(2), 282-293.

Saplıoğlu, M., & Aydın, M. M. (2018). Choosing safe and suitable bicycle routes to integrate cycling and public transport systems. *Journal of Transport & Health, 10*, 236-252.

Willis, D. P., Manaugh, K., & El-Geneidy, A. (2015). Cycling under influence: summarizing the influence of perceptions, attitudes, habits, and social environments on cycling for transportation. *International Journal of Sustainable Transportation, 9*(8), 565-579.

Wu, R., Wu, Z., Wen, J., Cai, Y., & Li, Y. (2019). Extrinsic and intrinsic motivations as predictors of bicycle sharing usage intention: An empirical study for Tianjin, China. *Journal of cleaner production, 225*, 451-458.

Zuurbier, M., Willems, J., Schaap, I., Van der Zee, S., & Hoek, G. (2019). The contribution of moped emissions to ultrafine and fine particle concentrations on bike lanes. *Science of the total environment, 686*, 191-198.

DOI 10.26773/smj.210213

SportMont

ORIGINAL SCIENTIFIC PAPER

The Comparison of Analogue Pain Scale, Quadriceps Muscle, and Knee Joint among Obese Women with Knee Osteoarthritis

Nur Azis Rohmansyah[1,5], Syahruddin[2], Wulan Rahmadhani[3] and Ashira Hiruntrakul[4]

[1]Universitas PGRI Semarang, Department of Physical Education, Semarang, Indonesia, [2]Universitas Negeri Makasar, Faculty of Sport Sciences, Makasar, Indonesia, [3]Sekolah Tinggi Ilmu Kesehatan Muhammadiyah Gombong, Department of Midwifery, Kebumen, Indonesia, [4]Khon Kaen University, Department of Branch of Sport Science, Faculty of Applied Science and Engineering, Nong Khai Campus, Nong Khai, Thailand, [5]Khon Kaen University, Department of Exercise and Sport Sciences, Faculty of Graduate School, Khon Kaen, Thailand

Abstract

Introduction: Patients with knee osteoarthritis were reported to have quadriceps weakness and impaired knee function, related to pain. It is unclear whether body composition is a causal factor to the above findings. Aim: The purpose of this study was to investigate differences in pain, quadricep strength, and knee function among obese women and women of normal weight with knee osteoarthritis. Methods: Fifty women with a mean age of 55 years were involved in this study. The inclusion criteria were bilateral knee of knee osteoarthritis with a visual analogue pain scale difference (>1) between each knee. Patients all underwent assessment of the pain intensity, isokinetic strength of knee muscles, and knee function. Results: The analysis showed that there were significant differences between groups in pain intensity (p=0.004) and quadriceps strength (p=0.003) but were not significant on the Lequesne index score (p=0.05). Significant differences in the intensity of knee pain and quadriceps strength occurred between the obesity II group with the normal weight group (p=0.004), overweight (p=0.017) and with obesity I (p=0.017) suffering from knee osteoarthritis. Conclusion: Normal weight people with knee osteoarthritis are at risk of suffering knee pain that causes reduced physical activity. This inactive condition will also result in a decrease in quadriceps muscle strength, which can increase the risk of knee deformity. Therefore, proper education and training programmes are required to anticipate this, so as to prevent the progression of knee osteoarthritis.

Keywords: *obesity, knee osteoarthritis, analogue pain scale, quadriceps muscle, knee joint*

Introduction

Obesity prevalence has increased in all age groups; specifically, in 2018, 21.83% of the Indonesian population was considered obese (Kesehatan et al., 2019). Obesity is a complex and multifactorial disorder arising from interactions between genotypes and environmental factors, namely social, behavioural, cultural, physiological and metabolic (Michael, Schlüter-Brust, & Eysel, 2010; Ng et al., 2014). Some chronic diseases are associated with obesity, such as hypertension, type 2 diabetes mellitus, cardiovascular disease, respiratory disorders, and various musculoskeletal complications.

One of the most common musculoskeletal complications is knee osteoarthritis, which is a chronic disease that manifests as pain, stiffness, swelling, and muscle weakness (Neogi, 2013); it causes functional impairment due to lower limb muscle weakness and is one of the most common diseases in older persons (Bindawas & Vennu, 2015). Knee osteoarthritis very often causes disability and is progressive, which is expe-

Correspondence:

N. A. Rohmansyah
Universitas PGRI Semarang, Department of Physical Education, Jl. Sidodadi Timur Nomor 24 - Dr. Cipto, Semarang, Indonesia
Email: nurazisrohmansyah@kkumail.com

rienced by nearly 80% of people aged 55 years (Im & Kim, 2014). Pain in knee osteoarthritis is closely related to decreasing quadriceps strength (Messier, Glasser, Ettinger, Craven, & Miller, 2002). Meanwhile, quadriceps muscle weakness may contribute to the worsening of knee pain (Segal et al., 2010). Also, quadriceps strength is one of the intrinsic factors affecting knee functions (Palmieri-Smith, Thomas, Karvonen-Gutierrez, & Sowers, 2010).

Obesity is a critical risk factor in the progression of knee osteoarthritis. Various studies have consistently shown an association between obesity as measured by body weight or body mass index (BMI), with the prevalence and incidence of knee osteoarthritis. One of them is a survey conducted by the National Health and Nutrition Examination Survey, showing that the risk of knee osteoarthritis increases almost four times in women with obesity, and 4.8 times in men who are obese (Ho-Pham, Lai, Mai, Doan, & Nguyen, 2016). During the single-leg stance phase, the knee will take 3-6 times body weight (Melchiorre, 1996). Each weight gain will be multiplied by this number, illustrating how much weight passes through the knee on someone who has more weight when walking. The increase in axial load will cause a resultant shift in the force acting on the knee joint towards the medial and an increase in knee adduction movement on the knee thereby increasing the load that passes through the medial compartment of the knee, which can trigger knee osteoarthritis, especially in the medial compartment of the knee (Melchiorre, 1996). Among obese people who also experience knee osteoarthritis, there is an increase in knee pain that causes limited activity, as well as the risk of needing a knee joint replacement (Ho-Pham et al., 2016).

According to Landsmeer et al. (2019) a linear relationship between BMI and the incidence of disability due to knee pain due to knee osteoarthritis exists, which is thought to be because an increase in body weight will increase the axial load that passes through the knee joint, resulting in higher pain intensity. Patients will tend to rest their knees by decreasing physical activity, causing quadriceps muscle weakness and atrophy. Furthermore, quadriceps muscle weakness that occurs in obese sufferers who experience knee osteoarthritis can be aggravated by the fatigue in quadriceps muscle due to the large load at the time of weight-bearing and sedentary lifestyle that is common among obese people. Weakness in the knee extensor muscle can cause knee weights to increase 21% higher compared to healthy knees (Mikesky et al., 2006). Furthermore, overloading with quadriceps muscle weakness can increase the risk of deformity in the knee of an osteoarthritis sufferer. The above factors are thought to cause higher progression in obese people with knee osteoarthritis in comparison to people of normal weight with knee osteoarthritis (Madry et al., 2016). Disease progression that is not handled properly can increase a person's disability, especially in walking, the ability to climb stairs, rise from sitting and standing for an extended period. The disability will reduce independence in the activities of daily life and the quality of life and ultimately can cause handicaps. However, there are limited studies regarding pain, quadriceps strength, and knee function in obese women with knee osteoarthritis compared to normal-weight people with knee osteoarthritis.

The purpose of this study was to investigate the differences in the analogue pain scale, quadriceps muscle, and knee joint between obese and normal-weight sufferers with knee osteoarthritis.

Methods

Study design and Participants

The design of this study was cross-observational. Fifty female participants were included in this study: 25 participants with normal weight (BMI<25 kg/m²) and 25 participants with obesity (BMI≥25 kg/m²), classified as Asian Pacific (World Health Organization, 2000), aged 40-59 years old, who had a diagnosis of knee osteoarthritis, according to the American College of Rheumatology criteria (Altman et al., 1986). Both knee joints had arthritic change grade 2 or higher in the Kellgren-Lawrence grading scale (Kellgren & Lawrence, 2006); both knees had pain without swelling confirmed by ultrasonography, performed by a senior radiologist who had performed ultrasonography for more than five years; the difference of visual analogue scale (VAS) was less than eight points between each knee joint. The satisfaction of the inclusion criteria was confirmed based on a health history questionnaire.

Subjects who experienced knee joint infections or other joint abnormalities in the lower extremities were obese after the occurrence of knee osteoarthritis, had impaired balance, proprioceptive sense and coordination, laxity in the collateral ligament of the knee joint, valgus and varus deformity, prosthesis and orthosis which serves to correct the joints of the knee joint limitations of the scope of the knee joint, neuromuscular disease (i.e., stroke and peripheral neuropathy), cardiovascular disease and hypertension were excluded.

Settings and locations of data collection

The research was conducted in Central Java, Indonesia (Semarang and Gombong). The testing took place in the Rehabilitation Laboratory of the Physical Education of Universitas PGRI Semarang and the Laboratory of Midwifery of the Sekolah Tinggi Ilmu Kesehatan Muhammadiyah Gombong. The baseline study was started in May 2019 and ended in July 2019.

Outcome measures

In this study, the participants were given a clear explanation of the measured parameters and methods of measurement. For each testing protocol, all participants received verbal directives and visual demonstrations from the examiner. The participants warmed up prior to the measurement.

Each subject had X-ray radiographs of both knees and completed pain evaluation as part of the study. Using the VAS scale, a score between 0 to 10 points of the combined pain in both knees was obtained, followed by separate scores for each knee, to identify which was more and less painful. At the same time, quadriceps strength tests were performed after approximately 10 min of warm-up consisting of the stretches to hamstring, quadriceps, and calf muscles, and then a light level of stationary bike exercise.

An a priori power analysis was performed to determine the sample size using a two-sided hypothesis test at an alpha level of 0.05 and a power of 0.8. The results of a previous study indicated that 25 knees would be required to detect a significant between-group joint proprioception difference of >1°, the primary outcome measure (Hurley, Scott, Rees, & Newham, 1997).

All observations and measurements were carried out by the same investigator. The body mass and height of each participant were measured to calculate their BMI by dividing body mass (kg) by height in meters squared (m^2). After an overnight fast, body composition was measured by bioelectrical impedance analysis equipment (Body Composition Analyser Tanita AB-140 Viscan, Tanita Corporation of America, Inc., USA). Height was measured with a stadiometer. The strength and endurance of the knee extensor and flexor muscles were evaluated using an isokinetic dynamometer (CSMI Medical Solutions, MA, USA). The maximal strength of the quadriceps and hamstring was measured for each knee at 60 °/s (4 repetitions) and 180 °/s (20 repetitions), and mean power for each was calculated (Gur & Cakin, 2003). The maximum peak torque (Nm) for each velocity was also recorded. This measure has excellent intra-rater reliability in patients with knee osteoarthritis (Kean, Birmingham, Garland, Bryant, & Giffin, 2010). VAS scale measurements, quadriceps strength, and Lequesne Functional Index (Basaran, Guzel, Seydaoglu, & Guler-Uysal, 2010) from the normal weight and obese women groups were compared at the end of the study.

Written informed consent was provided by the participants, and all procedures were handled according to the Declaration of Helsinki. The study obtained approval from the ethics committee of Universitas PGRI Semarang.

Statistical analysis

Statistical analysis was performed using SPSS version 22 (SPSS Inc., Chicago, IL, USA). The normality of all data was checked using the Shapiro-Wilk test ($p>0.05$). A paired t-test was used to compare the difference in muscle strength between the two groups. The difference in pain intensity and quadriceps strength was determined using the One Way Anova test, while differences in knee function were determined using the Kruskal Wallis test. Post hoc analysis was carried out to find differences between groups. Statistical significance was accepted at $p<0.05$.

Results

There was a total of 50 female patients in this study. The detail of the demographic data was shown in Table 1.

Table 1. Characteristics of subjects

Characteristics	Obesity	Non-obesity
Age (years)	55±2.7	55±17
BMI (kg/m²)	28.93±2.33	23.84±1.3
Dominant leg (right/left)	23/2	18/7
More painful knee (right/left)	17/8	14/11
Duration of knee pain		
<6 months	5	7
6-12 months	9	12
>12 months	11	6
Visual analogue scale	5.90±1.39	3.53±1.37

This study showed no significant difference in the intensity of knee pain as measured by VAS ($p=0.06$). In the obese and normal groups, the mean VAS reported was 5.86±0.96 cm and 5.3±1.13 cm, respectively, for the obese group with knee osteoarthritis and the normal group with knee osteoarthritis. Obese subjects with knee osteoarthritis had lower quadriceps strength (127.87±13.51 N) compared to those in the normal group with knee osteoarthritis (117.82±15.02 N). The difference in quadriceps strength was statistically significant between the two ($p=0.016$). The Lequesne index score describes the knee function sufferers of knee osteoarthritis. In the obese group, the median score was 8, with a minimum score of 4 and a maximum score of 12.5. There was no significant difference between this group and the normal group who had a median of 6, with a minimum score of 4 and a maximum score of 12 ($p=0.139$). With respect to knee extensor muscle strength, the knees of obese subjects showed significantly lower strength than the knees of normal weight subjects at angular velocities of both 60°/s (54.98±13.36 Nm vs 63.00±9.96 Nm, $p=0.01$) and 180°/s (37.78±9.55 Nm vs 44.68±11.77 Nm, $p=0.01$). However, there was no statistically significant difference in knee flexor muscle strength at angular velocities of 60°/s or 180°/s either (Table 2).

Table 2. Results pain, quadriceps strength and knee function

Variable	Obesity M±SD	Non-obesity M±SD	p
VAS	5.86±0.96	5.3±1.3	0.06
Quadriceps strength	127.82±13.51	117.82±15.02	0.016*
Isokinetic peak torques (Nm)			
Extensor 60 °/sec	54.98±13.36	63.00±9.96	0.01*
Extensor 180 °/sec	37.78±9.55	44.68±11.77	0.01*
Flexor 60 °/sec	27.10±6.70	29.88±6.57	0.06
Flexor 180 °/sec	23.30±7.25	25.50±5.61	0.07
Lequesne index score	8 (4-12.5)**	6 (4-12)**	0.139

Legend: M±SD - mean ± standard deviation (*p < 0.05; *Median (min-max))

The analysis showed that there were significant differences between groups in pain intensity (p=0.004) and quadriceps strength (p=0.003), but they were not significant on the Lequesne index score (p=0.05). Significant differences in intensity of knee pain and quadriceps strength occurred between the obesity II group both with the normal weight group (p=0.004), overweight (p=0.017) and with obesity I (p=0.017) suffering from knee osteoarthritis. There were no significant differences in the Lequesne index scores between the four groups. No significant differences in pain intensity, quadriceps strength, and knee function were also found between normal-overweight, normal-obesity I, and over-obese I weight groups (Table 3).

Table 3. Differences in pain, quadriceps strength and knee function based on BMI classification

Variable	p
Pain	
Normal weight-obesity II	0.004
Overweight-obesity II	0.017
Obesity I-obesity II	0.017
Quadriceps strength	
Normal weight-obesity II	0.014
Overweight-obesity II	0.002
Obesity I-obesity II	0.025
Knee function	
Normal weight-obesity II	0.118
Overweight-obesity II	0.066
Obesity I-obesity II	0.121

Discussion

The results of this study indicate that there is no significant difference in pain intensity in the obese and normal groups with knee osteoarthritis. This result is not in accordance with the research of Marks (2007), which shows that there is a relationship between obesity and pain intensity: subjects who have a higher BMI complain of significantly higher pain intensity than subjects who have a lower BMI do. The research of Cimmino, et al. (2005) states that in addition to body mass index, pain intensity is also influenced by several other factors: female sex, age over 70 years, low level of education (defined as formal education less than five years), BMI >30, duration of illness more than seven years, the presence of comorbidities, and generalized knee osteoarthritis. The population of the study subjects were all women, none were over 70 years old, there was only one person who had knee pain longer than seven years, three people who had comorbidities (dyslipidaemia and diabetes mellitus), all were in the obesity group, and there were no subjects who experienced generalized knee osteoarthritis. Homogeneity and the low sample size with accompanying factors that emerged in the study population caused researchers to suspect that these factors did not affect the absence of differences in the intensity of knee pain experienced by subjects in the two study groups. This study shows a statistically significant difference in pain intensity between the obesity II BMI (>30 kg/m²) with the normal weight, overweight, and obese I groups who suffer from knee osteoarthritis. This is consistent with the research of Cimmino, et al. (2007), which determined there is a significant relationship between BMI >30 kg/m² with the intensity of pain complained of by patients with knee osteoarthritis. Also, Jinks et al. (2006) asserted that a BMI >30 kg/m² was also a strong predictor for the progression of mild pain to pain with severe intensity after three years. The available evidence corroborates the alleged relationship between an increase in body mass index and variations in pain conditions. In weight-bearing joint osteoarthritis, such as knee and hip, mechanical-structural factors are thought to play a greater role in the relationship between BMI and knee osteoarthritis complaints (Janke, Collins, & Kozak, 2007). Research by Thorp et al. (2007) has shown that, for subjects with mild knee osteoarthritis, radiography plays an important role in calculating the increased burden on the knee compartment from the knee adduction moment, which is significantly related to the increase in pain complaints. Metabolic factors that are thought to play a role in the relationship between obesity and pain intensity are changes in glucose homeostasis. Glucose homeostasis may also be an important factor related to pain (Janke, Collins, & Kozak, 2007). Pain experienced by obese sufferers with knee osteoarthritis will make the subject reduce his physical activity so that there is an increase in body weight and deconditioning including the quadriceps muscle which in turn can further increase the pain (Janke et al., 2007). Significant decreases in muscle strength decreased between groups with a BMI >30 kg/m² (obesity II) and groups with a BMI below it. Although there were no significant differences, quadriceps strength tended to decrease between groups of normal weight, overweight, and obesity I. The results of this study are in accordance with the research of Amin et al. (2009) who found that there was a strong significant negative correlation between body weight and knee extensor strength. The relationship between quadriceps muscle weakness and obesity is thought to be due to an increase in body weight, which increases the axial load that passes through the knee joint, resulting in higher pain intensity. This finding is supported by the research of Roos et al. (2011), states that obese individuals have quadriceps muscles with lower resistance to fatigue than individuals without obesity.

Furthermore, quadriceps muscle weakness can also be caused and aggravated by the lifestyle of individuals with obesity, who tend to be sedentary. The strength of the concentric contraction, as well as the eccentric muscles of the quadriceps, are weaker in transient women (Lim et al., 2009). Research subjects in the obese group with average knee osteoarthritis experienced severe functional impairment (median Lequesne index 8). Although not statistically significant, subjects in that group had a more severe disability compared to subjects in the normal group with knee osteoarthritis, who on average experienced moderate functional impairment (median Lequsne index 6). The results of this study did not show significant differences in the knee function between obese and normal sufferers with knee osteoarthritis, which is in contrast to the study of Teichtahl et al. (2008), which found that there is a linear correlation between BMI and the incidence of disability in patients with knee osteoarthritis. According to Creamer et al. (2000), the intensity of pain, obesity and feeling of helplessness are the factors most related to disability. The subjects in this study had a mean pain intensity that was not significantly different in the two groups, and the mean BMI in the normal group was near the upper limit of weight classification more in line with the Asia Pacific classification. The two factors that are almost the same might cause the level of knee function ability, which is not significantly different between the obese group and without obesity with knee osteoarthritis.

Based on the results of previous studies, a decrease in muscle strength is also believed to be a factor that affects the reduced knee function in patients with knee osteoarthritis (Dekker, Van Dijk & Veenhof, 2009; Sharma, Lou, Cahue & Dunlop, 2000). Decreased quadriceps strength, is a risk factor for the progression of knee osteoarthritis, due to reduced muscle ability to accurately control joint movement (Roos et al., 2011).

In the present study, the quadriceps strength of the subjects in the obese group was significantly lower compared to the normal group with knee osteoarthritis. However, this did not seem to affect the Lequesne index reported by the study subjects in the two groups, so there was no significant difference in knee function in the two groups. This can occur because, in addition to muscle strength factors, there are still many other risk factors that cause a decrease in the ability of knee function that were not examined in this study.

In this study, the presence of comorbidity is only sought based on history and simple physical examination on the subject of research, so that there may still be other undetectable comorbidity factors that could affect the results. Other than the existence of the aforementioned factors, psychological and social disorders can also be a confounding factor, especially in the analysis of differences in the functional ability of the knee between the obese and non-obese groups with knee osteoarthritis.

Obesity, especially obesity II, has been shown to have a large influence on the level of pain intensity and decreasing quadriceps strength. Given significant decreases in muscle strength in obese people with knee osteoarthritis, it is necessary to strengthen the muscle with exercise, especially quadriceps and hamstring, which will be very beneficial in maintaining knee stability and reducing the burden that passes through the knee joint.

Acknowledgements

The research was funded by Khon Kaen University. The author thanks the research investigator and study participants.

Conflict of Interest

The authors declare that there is no conflict of interest.

Received: 04 May 2020 | **Accepted:** 28 June 2020 | **Published:** 01 February 2021

References

Altman, R., Asch, E., Bloch, D., Bole, G., Borenstein, D., Brandt, K., ... Wolfe, F. (1986). Development of criteria for the classification and reporting of osteoarthritis. Classification of osteoarthritis of the knee. Diagnostic and Therapeutic Criteria Committee of the American Rheumatism Association. *Arthritis and rheumatism*, *29*(8), 1039-49. doi: 10.1002/art.1780290816

Amin, S., Baker, K., Niu, J., Clancy, M., Goggins, J., Guermazi, A., Grigoryan, M., Hunter, D. J., & Felson, D. T. (2009). Quadriceps strength and the risk of cartilage loss and symptom progression in knee osteoarthritis. *Arthritis and Rheumatism*., 60(1), 189-98. doi: 10.1002/art.24182

Basaran, S., Guzel, R., Seydaoglu, G., & Guler-Uysal, F. (2010). Validity, reliability, and comparison of the WOMAC osteoarthritis index and Lequesne algofunctional index in Turkish patients with hip or knee osteoarthritis. *Clinical Rheumatology*, *29*(7), 749-56. doi:10.1007/s10067-010-1398-2

Bindawas, S. M. & Vennu, V. (2015). Longitudinal effects of physical inactivity and obesity on gait speed in older adults with frequent knee pain: Data from the osteoarthritis initiative. *International Journal of Environmental Research and Public Health*, *12*(2), 1849-63. doi: 10.3390/ijerph120201849

Cimmino, M. A., Sarzi-Puttini, P., Scarpa, R., Caporali, R., Parazzini, F., Zaninelli, A., & Marcolongo, R. (2005). Clinical presentation of osteoarthritis in general practice: Determinants of pain in Italian patients in the AMICA study. *Seminars in Arthritis and Rheumatism*, *35*(1 Suppl 1), 17-23. doi: 10.1016/j.semarthrit.2005.01.015

Creamer, P., Lethbridge-Cejku, M., & Hochberg, M. C. (2000). Factors associated with functional impairment in symptomatic knee osteoarthritis. *Rheumatology*, *39*(5), 490-6. doi: 10.1093/rheumatology/39.5.490

Dekker, J., Van Dijk, G. M., & Veenhof, C. (2009). Risk factors for functional decline in osteoarthritis of the hip or knee. *Current Opinion in Rheumatology*, *21*(5), 520-4. doi:10.1097/BOR.0b013e32832e6eaa

Janke, E. A., Collins, A., & Kozak, A. T. (2007). Overview of the relationship between pain and obesity: What do we know? Where do we go next? *Journal of Rehabilitation Research and Development*, *44*(2), 245-62. doi: 10.1682/jrrd.2006.06.0060

Gur, H. & Cakin, N. (2003). Muscle mass, isokinetic torque, and functional capacity in women with osteoarthritis of the knee. *Archives of physical medicine and rehabilitation*, *84*(10), 1534-41

Ho-Pham, L. T., Lai, T. Q., Mai, L. D., Doan, M. C., & Nguyen, T. V. (2016). Body Composition in Individuals with Asymptomatic Osteoarthritis of the Knee. *Calcified Tissue International*, *98*(2), s.165–171. doi:10.1007/s00223-015-0080-8

Hurley, M. V., Scott, D. L., Rees, J., & Newham, D. J. (1997). Sensorimotor changes and functional performance in patients with knee osteoarthritis. *Annals of the Rheumatic Diseases*, *56*(11), 641–648. doi: 10.1136/ard.56.11.641

Im, G. Il & Kim, M. K. (2014). The relationship between osteoarthritis and osteoporosis. *Journal of Bone and Mineral Metabolism*, *32*(2), 101-9. doi: 10.1007/s00774-013-0531-0

Janke, E. A., Collins, A., & Kozak, A. T. (2007). Overview of the relationship between pain and obesity: What do we know? Where do we go next? *Journal of Rehabilitation Research and Development*, *44*(2), 245-62. doi: 10.1682/jrrd.2006.06.0060

Jinks, C., Jordan, K., & Croft, P. (2006). Disabling knee pain - Another consequence of obesity: Results from a prospective cohort study. *BMC Public Health*, *19*(6), 258. doi: 10.1186/1471-2458-6-258

Kean, C. O., Birmingham, T. B., Garland, S. J., Bryant, D. M., & Giffin, J. R. (2010). Minimal detectable change in quadriceps strength and voluntary muscle activation in patients with knee osteoarthritis. *Archives of Physical Medicine and Rehabilitation*, *91*(9), 1447-51. doi: 10.1016/j.apmr.2010.06.002

Kellgren, J. & Lawrence, J. (2006). Classification and epidemiology of osteoarthritis. *Oxford University Press, Oxford (UK)*, *74*(8), 1886–1893. doi: 10.1007/s11999-016-4732-4

Kementerian Kesehatan RI (2019). Ministry of Health Republic of Indonesia. Retrieved 01/22, 2019 from: http://www.depkes.go.id/resources/download/pusdatin/profil-kesehatan-indonesia/profil-kesehatan-indonesia-2018.pdf

Landsmeer, M. L. A., Runhaar, J., van Middelkoop, M., Oei, E. H. G., Schiphof, D., Bindels, P. J. E., & Bierma-Zeinstra, S. M. A. (2019). Predicting Knee Pain and Knee Osteoarthritis among Overweight Women. *The Journal of the American Board of Family Medicine*, *32*(4), s.575–584. doi:10.3122/jabfm.2019.04.180302

Lim, B. W., Kemp, G., Metcalf, B., Wrigley, T. V., Bennell, K. L., Crossley, K. M., & Hinman, R.S. (2009). The association of quadriceps strength with the knee adduction moment in medial knee osteoarthritis. *Arthritis Care and Research*, *61*(4), 451-8. doi: 10.1002/art.24278

Madry, H., Kon, E., Condello, V., Peretti, G. M., Steinwachs, M., Seil, R., Berruto, M., Engebretsen, L., Filardo, G., & Angele, P. (2016). Early osteoarthritis of the knee. *Knee Surgery, Sports Traumatology, Arthroscopy*, *24*(6), 1753-62. doi: 10.1007/s00167-016-4068-3

Marks, R. (2007). Obesity profiles with knee osteoarthritis: Correlation with pain, disability, disease progression. *Obesity*, *5*(7), 1867-74. doi: 10.1038/oby.2007.221

Melchiorre, P. J. (1996). Brunnstrom's Clinical Kinesiology. *American Journal of Physical Medicine & Rehabilitation*, *75*(3), p.197. doi: 10.1097/00002060-199605000-00009

Messier, S. P., Glasser, J. L., Ettinger, W. H., Craven, T. E., & Miller, M. E. (2002). Declines in strength and balance in older adults with chronic knee pain: A 30-month longitudinal, observational study. *Arthritis & Rheumatism*, *47*(2), 141-8. doi: 10.1002/art.10339

Michael, J. W.-P., Schlüter-Brust, K. U., & Eysel, P. (2010). The Epidemiology, Etiology, Diagnosis, and Treatment of Osteoarthritis of the Knee. *Deutsches Aerzteblatt Online*, *107*(9), 152-62. doi: 10.3238/arztebl.2010.0152

Mikesky, A. E., Mazzuca, S. A., Brandt, K. D., Perkins, S. M., Damush, T., & Lane, K. A. (2006). Effects of strength training on the incidence and progression of knee osteoarthritis. *Arthritis Care and Research*, *55*(5), 690-9. doi: 10.1002/art.22245

Neogi, T. (2013). The epidemiology and impact of pain in osteoarthritis. *Osteoarthritis and Cartilage*, *21*(9),1145-53. doi: 10.1016/j.joca.2013.03.018

Ng, M., Fleming, T., Robinson, M., Thomson, B., Graetz, N., Margono, C., ... Gakidou, E. (2014). Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: A systematic analysis for the Global Burden of Disease Study 2013. *The Lancet*, *384*(9945), 766-81. doi: 10.1016/S0140-6736(14)60460-8

Palmieri-Smith, R. M., Thomas, A. C., Karvonen-Gutierrez, C., & Sowers, M. F. (2010). Isometric quadriceps strength in women with mild, moderate, and severe knee osteoarthritis. *American Journal of Physical Medicine and Rehabilitation*, *89*(7), 541-8. doi: 10.1097/PHM.0b013e3181ddd5c3

Roos, E. M., Herzog, W., Block, J. A., & Bennell, K. L. (2011). Muscle weakness, afferent sensory dysfunction and exercise in knee osteoarthritis. *Nature Reviews Rheumatology*, *7*(1), 57-63. doi: 10.1038/nrrheum.2010.195

Segal, N. A., Glass, N. A., Torner, J., Yang, M., Felson, D. T., Sharma, L., Nevitt, M., & Lewis, C. E. (2010). Quadriceps weakness predicts risk for knee joint space narrowing in women in the MOST cohort. *Osteoarthritis and Cartilage*, *18*(6), 769-75. doi: 10.1016/j.joca.2010.02.002

Sharma, L., Lou, C., Cahue, S., & Dunlop, D. D. (2000). The mechanism of the effect of obesity in knee osteoarthritis: The mediating role of malalignment. *Arthritis and Rheumatism*, *43*(3), 568-75. doi: 10.1002/1529-0131(200003)43:3<568::AID-ANR13>3.0.CO;2-E

Teichtahl, A. J., Wang, Y., Wluka, A. E., & Cicuttini, F. M. (2008). Obesity and knee osteoarthritis: New insights provided by body composition studies. *Obesity*, *16*(2), 232-40. doi: 10.1038/oby.2007.30

Thorp, L. E., Sumner, D. R., Wimmer, M. A., & Block, J. A. (2007). Relationship between pain and medial knee joint loading in mild radiographic knee osteoarthritis. *Arthritis, 57*(7), 1254-60. doi: 10.1002/art.22991

World Health Organization (2000). The Asia-Pacific perspective: redefining obesity and its treatment. Geneva, Switzerland: World Health Organization. Retrieved 01/22, 2019 from: http://www.wpro.who.int/nutrition/documents/docs/Redefiningobesity.pdf

DOI 10.26773/smj.210216

ORIGINAL SCIENTIFIC PAPER

Physical Activity and Nutritional Status of Schoolchildren in Montenegro

Milica B. Martinovic[1], Marina Z. Jaksic[1,2], Ersin S. Spahic[1], Milos Z. Lukic[3], Mirjana M. Nedovic-Vukovic[4]

[1]University of Montenegro, Medical Faculty, Department of Pathophysiology and Laboratory Medicine, Podgorica, Montenegro, [2]Clinical Center of Montenegro, Institute for Children's Diseases, Center for Laboratory Diagnostics, Podgorica, Montenegro, [3]Clinical Center of Montenegro, Department of Internal Medicine, Podgorica, Montenegro, [4]Institute for Public Health of Montenegro, Center for Health System Development, Department for Health Statistics and Informatics, Podgorica, Montenegro

Abstract

This study aimed to investigate the association between nutritional status and physical activity in urban and rural school children in Montenegro, by presenting part of the results of the national survey on childhood obesity in Montenegro (2013-2015). The sample included 4725 Montenegrin children: 2381 (50.4%) boys and 2344 (49.6%) girls. The self-administered part of the questionnaire for parents included four questions on children's physical activity. Anthropometric measurements were taken in schools. Nutritional status was assessed according to the criteria of the U.S. Centers for Disease Control and Prevention (CDC). In the present study, boys reported more physical activity than girls did (sports, outdoor play, etc.). The reported share of engagement in various team sports (football, basketball) was also higher among the boys than the girls. Rural children reported being more physically active than children in urban areas, and their scheduled physical education classes attendance was higher compared with their urban peers. There were no differences between children in rural and urban areas with respect to participation in individual/team sports. Obese children reported a significantly lower level of physical activity compared with normal-weight children. The obtained results suggest that the promotion of physical activity should be emphasized in an interdisciplinary as a way of prevention of childhood obesity as one of the significant public health challenges in the 21st century.

Keywords: *children, physical activity, nutritional status, urban, rural*

Introduction

Obesity is a complex multifactorial disease with numerous biological, behavioural and environmental determinants (Mead et al., 2017). Childhood obesity has become a leading public health challenge of the 21st century. According to the World Health Organization (WHO), globally, in 2016, the number of overweight children under the age of five was estimated to be over 41 million (World Health Organization, 2020). Additionally, over 340 million children and adolescents aged 5–19 were overweight or obese in 2016. The prevalence of overweight and obesity among children and adolescents aged 5–19 has risen dramatically worldwide from just 4% in 1975 to over 18% in 2016; the rise has occurred similarly among both boys and girls (World Health Organization, 2020). According to the recent Montenegrin national survey data, the overall percentage of Montenegrin schoolchildren who were overweight or obese (U.S. Centers of Disease Control and Prevention -CDC criteria) was 24.5%, of which 9% were obese (Martinovic et al., 2015).

Childhood obesity is associated with adverse consequences, such as psychological problems and lower educational attainment, and a higher risk of many harmful comorbidities later in life, including type 2 diabetes mellitus, dyslipidemia, non-alcoholic fatty liver disease, coronary heart disease, hypertension, locomotor disorders, infertility, and even cancer (Spinelli et al., 2019; World Health Organization, 2020). According to some researchers, childhood obesity is affecting mainly low and middle-income countries, particularly in urban settings (World Health Organization, 2020), although some systematic reviews and meta-analyses provide evi-

Correspondence:

M. Martinovic
University of Montenegro, Medical Faculty, Department of Pathophysiology and Laboratory Medicine, Krusevac bb, 81000, Podgorica, Montenegro
E-mail: milicam@ucg.ac.me

dence that raised odds of childhood obesity are found more in rural areas (J. A. Johnson & A. M. Johnson, 2015). However, most evidence shows that regardless of whether children live in an urban or rural setting, the increasingly digitalized world conquers both areas and offers fewer opportunities for physical activity through healthy play (World Health Organization, 2020). It seems that being overweight or obese further reduces children's opportunities to participate in individual or group physical activities, which is often a circulus vitiosus problem: children become even less physically active, which makes them likely to become more overweight and obese over time (World Health Organization, 2020). Many children nowadays grow up in an obesogenic environment that promotes energy imbalance through the marketing, advertising, affordability and availability of energy-dense foods, coupled with decreases in physical activity and increases in sedentary lifestyle habits (playing computer games, watching TV, etc.) (Mead et al., 2017). Consistently with this, some data show that children today are about 15% less fit compared with how fit their parents were when they were young (Chen, Hammond-Bennett, Hypnar, & Mason, 2018).

Regular physical activity in children and adolescents promotes health and fitness. Authorities recommend that children and adolescents aged 6 to 17 engage in 60 minutes or more of moderate-to-vigorous physical activity daily. Compared with those who are inactive, physically active youth have higher levels of fitness, lower body fat, stronger bones and muscles and lower risk of cardiometabolic diseases (U.S. Department of Health and Human Services, 2018).

Many epidemiological studies have confirmed this close association between physical activity, physical fitness and adiposity in school-aged children and youth, while longitudinal studies reported an unquestionable inverse relationship between body mass index (BMI) and physical fitness (Koulouvaris, Tsolakis, Tsekouras, Donti, & Papagelopoulos, 2018). Therefore, physical activity should be considered very important for promoting good health in children. Children spend half of their daily hours and consume at least one-third of their daily calories at school; thus, schools are recognized as an ideal place for implementing the obesity interventions to most children (Liu et al., 2019).

The goal of obesity prevention can be achieved by improvement of energy balance-related behaviours, which includes both physical activity and dietary improvement, which can be changed through the environmental influence, especially physical education curriculum improvement (Liu et al., 2019).

This study aimed to investigate the association between nutritional status and physical activity in urban and rural school children in Montenegro.

Methods

We performed a cross-sectional national study among Montenegrin elementary school children from second to seventh grade. Details of data collection methods have been described in previous reports (Martinovic et al., 2015). The final sample included 2381 (50.4%) boys and 2344 (49.6%) girls, aged 7–13 years (mean±SD=9.79±1.71 years).

In the national study, the parental questionnaire was self-administered and consisted of five parts. For this study, we chose the parts of the questionnaire related to gender, age, urban vs rural residential area, and child's physical activity. The questions on physical activity were taken from a standardized questionnaire (Kerr et al., 2008) and were related to various types of school and out-of-school physical activities (individual/team sports, walk to school, outdoor play, etc.) weekly, at least one hour per day.

Weight measurements were performed on barefoot children in light clothes on a digital scale with accuracy up to 0.1 kg. Body height was measured with stadiometer with accuracy up to 0.5 cm. Body mass index (BMI) was calculated by dividing their body weight in kilograms by the square of their height in metres.

We assessed the children's nutritional status using anthropometric criteria of the U.S. Centers for Disease Control and Prevention. In CDC Growth Charts for children and adolescents age 2 to 19, BMI is assessed by age- and sex-specific percentiles: underweight is < 5th percentile; normal weight is 5th percentile to less than the 85th percentile; overweight is the 85th percentile to less than the 95th percentile, and obesity is ≥ 95th percentile (Centers for Disease Control and Prevention, 2018).

Statistical analysis was performed in IBM SPSS Statistics for Windows, Version 22.0. The chi-square test was used to test the difference in response frequency with respect to gender, urban/rural residence and nutritional status of children based on CDC anthropometric assessment criteria (p-value less than 0.05 was considered significant).

Results

A small percentage of children (0.8% of boys and 1.6% of girls) reported not being physically active at least one hour per

Table 1. Frequency of responses by gender, place of residence of children (rural/urban) and nutritional status for the question: Over a typical or usual week on how many days is your child physically active for a total of at least 60 minutes per day? Response rate: 95%

	0 days	1 day	2 days	3 days	4 days	≥ 5 days	p
Gender	Number (%)						
Boy	19 (0.8)	84 (3.7)	166 (7.3)	237 (10.4)	241 (10.6)	1524 (67.1)	<0.001
Girl	35 (1.6)	87 (3.9)	189 (8.5)	316 (14.2)	261 (11.7)	1345 (60.2)	
Urban/rural							
Rural	5 (0.6)	25 (3.1)	72 (8.9)	116 (14.3)	73 (9.0)	520 (64.1)	0.029
Urban	44 (1.4)	129 (4.2)	251 (8.1)	375 (12.1)	361 (11.6)	1942 (62.6)	
Nutritional status							
Underweight	1 (0.4)	11 (4.2)	23 (8.8)	38 (14.5)	23 (8.8)	166 (63.4)	0.001
Normal weight	36 (1.1)	123 (3.9)	257 (8.1)	372 (11.8)	327 (10.4)	2044 (64.7)	
Overweight	5 (0.7)	19 (2.8)	48 (7.0)	92 (13.4)	91 (13.2)	433 (62.9)	
Obese	12 (3.0)	18 (4.6)	27 (6.8)	51 (12.9)	61 (15.4)	226 (57.2)	

Legend: p - statistical significance

day a week (Table 1). Most examined children (boys and girls) reported being physically active for at least one hour, five days a week (sports, walk to school, outdoor play, etc.). Boys more frequently reported being physically active for at least one hour during four or more days a week; this difference was statistically significant when compared to girls (67.1% vs 60.2%; p<0.001). Most children from both rural (64.1%) and urban areas (62.6%) reported being physically active for at least one hour during five or more days a week (Table 1). A statistically significant difference was found between rural and urban children in respect to their physical activity responses, in favour of rural children. Children who live in rural areas of Montenegro reported being more physically active during the week when compared to their urban peers (p=0.029). In all four nutritional status categories of children, the most frequent response given regarding physical activity was "at least one hour during five or more days weekly". The most physically active were normal-weight children. In contrast, obese children reported lower levels of physical activity than their normal-weight peers did (p=0.001) (Table 1).

Boys' participation in team sports was significantly higher than girls' participation (p<0.001) although more than a third of the boys and more than half of the girls were not involved in club sports (football, basketball, etc.). There was no difference in club or team sport participation between rural and urban children (p=0.491). The majority of children in all four categories of nutritional status responded not being involved in any team sport (underweight 53.2%, normal-weight 44.7%, overweight 46.0%, obese 43.4%), while a statistically significant difference was observed between the responses (p=0.021) (Table 2).

Table 2. Frequency of answers by gender, place of residence of children (rural/urban) and nutritional status to the question: Outside of school, how many days per week does your child play or practice team sports? Response rate: 93%

	0 days	1 day	2 days	3 days	4 days	≥ 5days	p
Gender				**Number (%)**			
Boy	820 (36.8)	122 (5.5)	252 (11.3)	562 (25.2)	209 (9.4)	266 (11.9)	<0.001
Girl	1163 (54.0)	164 (7.6)	357 (16.6)	273 (12.7)	91 (4.2)	104 (4.8)	
Urban/rural							
Rural	358 (45.7)	63 (8.0)	109 (13.9)	134 (17.1)	55 (7.0)	65 (8.3)	0.491
Urban	1359 (45.7)	187 (6.2)	422 (13.9)	602 (19.8)	214 (7.0)	252 (8.3)	
Nutritional status							
Underweight	132 (53.2)	26 (10.5)	25 (10.1)	31(12.5)	13 (5.2)	21 (8.5)	0.021
Normal weight	1370 (44.7)	208 (6.8)	432 (14.1)	574 (18.7)	216 (7.0)	268 (8.7)	
Overweight	313 (46.0)	31 (4.6)	85 (12.5)	155 (22.8)	45 (6.6)	51 (7.5)	
Obese	168 (43.4)	21 (5.4)	67 (17.3)	75 (19.4)	26 (6.7)	30 (7.8)	

In our study, 63.6% of the boys and 59.3% of the girls were not engaged in non-team (individual) sports in general. Among the children who do participate in non-team sports, the share of boys versus the girls was significantly higher (p<0.001). There were no significant differences in the physical activity between urban and rural children (p=0.224); moreover, most children from both rural and urban areas (about 60%) reported not playing any non-team sports (Table 3).

Table 3. Frequency of responses by gender, place of residence of children (rural/urban) and nutritional status to the question: Outside of school, how many days per week does your child have activity training or instruction not in a team sport (e.g., martial arts, dance, tennis)? Response rate: 91%

	0 days	1 day	2 days	3 days	4 days	≥ 5days	p
Gender				**Number (%)**			
Boy	1359 (63.6)	125 (5.8)	196 (9.2)	269 (12.6)	76 (3.6)	112 (5.2)	<0.001
Girl	1269 (59.3)	207 (9.7)	352(16.4)	186 (8.7)	61 (2.8)	66 (3.1)	
Urban/rural							
Rural	475 (61.1)	66 (8.5)	88 (11.3)	97 (12.5)	24 (3.1)	27 (3.5)	0.224
Urban	1809 (61.3)	224 (7.6)	402 (13.6)	299 (10.1)	95 (3.2)	121 (4.1)	
Nutritional status							
Underweight	162 (66.4)	31 (12.7)	22 (9.0)	21 (8.6)	3 (1.2)	5 (2.0)	0.002
Normal weight	1829 (61.0)	247 (8.2)	384 (12.8)	305 (10.2)	100 (3.3)	134 (4.5)	
Overweight	407 (61.4)	37 (5.6)	85 (12.8)	87 (13.1)	22 (3.3)	25 (3.8)	
Obese	230 (61.8)	17 (4.6)	57 (15.3)	42 (11.3)	12 (3.2)	14 (3.8)	

We found no significant difference between reported physical education class attendance in terms of gender (p=0.091) and nutritional status (p=0.205). A significant difference between physical education class attendance was observed between rural and urban children (p<0.001). Rural children's attendance in physical education classes was much higher compared to that of urban children (Table 4).

Table 4. Frequency of responses by gender, place of residence of children (rural/urban) and nutritional status: How many days per week does your child have gym or physical education class at school? Response rate: 95%

	0 days	1 day	2 days	3 days	4 days	≥ 5days	p
Gender	**Number (%)**						
Boy	32 (1.4)	72 (3.2)	486 (21.9)	1448 (65.2)	163 (7.3)	21 (0.9)	<0.091
Girl	30 (1.3)	76 (3.4)	521 (23.4)	1459 (65.5)	132 (5.9)	9 (0.4)	
Urban/rural							
Rural	5 (0.6)	20 (2.5)	139 (17.3)	561 (70.0)	73 (9.1)	4 (0.5)	0.001
Urban	50 (1.6)	115 (3.8)	732 (23.9)	1952 (63.8)	187 (6.1)	25 (0.8)	
Nutritional status							
Underweight	3 (1.2)	6 (2.3)	60 (23.1)	180 (69.2)	11 (4.2)	0 (0.0)	0.205
Normal weight	40 (1.3)	102 (3.3)	716 (22.9)	2038 (65.2)	209 (6.7)	19 (0.6)	
Overweight	12 (1.8)	19 (2.8)	136 (20.1)	455 (67.3)	47 (7.0)	7 (1.0)	
Obese	7 (1.8)	21 (5.4)	95 (24.4)	234 (60.2)	28 (7.2)	4 (1.0)	

Discussion

This study evaluated the association of nutritional status with self-reported physical fitness indices in school-aged children (7–13). According to our results, the most physically active were normal-weight children. Quite the opposite, obese children reported lower levels of physical activity than their normal-weight peers. These findings confirmed that the 60 min/day guideline (World Health Organization, 2019) for children was negatively associated with overweight and obesity, which reveals that being physically active was associated with lower BMI, thus providing support for the role of physical activity in the maintenance of body weight and the prevention of obesity. These findings are consistent with results from numerous other studies (Dwyer, Baur, Higgs, & Hardy, 2009; Must & Anderson, 2006; Kelishadi et al., 2007). In addition, a significant negative relationship between physical activity (at least 60 minutes for five or more days a week) and overweight was also noted in a more extensive survey of 34 countries involving 162,305 school-aged participants (Janssen et al., 2005).

In all four nutritional status categories of children, the most frequent response given on physical activity was "at least one hour during five or more days weekly". This result does not match the 35% increase in obese Montenegrin schoolchildren from 2004 to 2015 (Martinovic et al., 2015), even though other contributing factors must be considered because of the multifactorial aetiology of obesity. There are also some reports of a growing prevalence of obesity in schoolchildren despite the high levels of physical activity (Tambalis, Panagiotakos, Kavouras, Papoutsakis, & Sidossis, 2013).

'Furthermore, we cannot exclude the possibility that social desirability led to an overestimation of the reported levels of physical activity; this is in contrast to Germany, where over three quarters of girls and two thirds of boys do not achieve the WHO's recommended levels of physical activity (Finger, Varnaccia, Borrmann, Lange, & Mensink, 2018). As seen in previous research, boys are generally more active than girls (Chung, Skinner, Steiner, & Perrin, 2012; Puyau, Adolph, Vohra, & Butte, 2002), which is concordant with our results. Some studies showed in both genders that physical activity levels decrease with age, especially during adolescence. The decrease is higher among younger girls (9–12 years) and older boys (13–16 years) (Puyau et al., 2002), and it manifests in many contexts, including active transportation, physical education classes and leisure physical activity (Cumming, Standage, Gillison, Dompier, & Malina, 2009; Dumith, Gigante, Domingues, & Kohl, 2011; Erlandson et al., 2011). Considering the age of our examinees, this could be one possible reason for this difference. A few studies also suggest that the mechanism of decline in physical activity among adolescents seems to be associated with age (Sherar, Cumming, Eisenmann, Baxter-Jones, & Malina, 2010). It is believed that biological maturation is a factor that can change the pattern of physical activity in children and adolescents. The early-maturing girls can have a decrease in interest in physical activity practice when they experience the physical changes of adolescence, such as increased fat deposition, breast development and hip enlargement, which may hinder the motor and physiological performance, and consequently reduce disposition for physical activity.

Furthermore, the increasing obligations in daily tasks can facilitate the reduction of physical activity. In contrast, the physical changes that occur in boys, such as a gain in height, body weight, higher proportion of lean mass and the widening of shoulders, are beneficial for participation in physical activity, as they result in a more appropriate physical build for success in many types of physical activity, particularly those that emphasize speed, power and strength (Bacil, Mazzardo Júnior, Rech, Legnani, & de Campos, 2015). R. M. Telford, R. D. Telford, Olive, Cochrane, and Davey (2016) highlighted the role of society as a whole and asked the question "Do we accept the premise that young girls are less physically active than boys as 'normal' or is it because we are failing to provide girls with the same level of opportunity and support to be equally active?" (McCrorie et al., 2020). A greater understanding of the mechanisms underlying this difference has the potential to guide physical activity intervention strategies.

In the present study, children who live in rural areas of Montenegro reported being more physically active during the week when compared with their urban peers. A similar difference in regards to the place of residence was found in Scottish study (McCrorie et al., 2020).

Organized sport is a specific type of physical activity and is typically defined as "organized, usually competitive, and can be played with a team or as an individual" (Eime, Young, Harvey, Charity, & Payne, 2013). The highest number of children regarding all four categories of nutritional status (over 60%) were not engaged in team or non-team sports either. In contrast, for example, in Australia, organized sport is popular among children, with two thirds of children aged 5–14 reporting participation in the previous 12 months (Active Healthy Kids Australia, Report 2016).

Based on the data of the present study, rural children's attendance in physical education classes was significantly higher than amongst urban children. There is no sufficient information to explain this phenomenon adequately, but numerous other studies have been reporting factors like lack of space and equipment being barriers to physical activity at schools, especially in developed countries (Morton, Atkin, Corder, Suhrcke, & van Sluijs, 2016). Overall, the results obtained suggest that the promotion of physical activity should be emphasized interdisciplinary as a way of prevention of childhood obesity as one of the significant public health challenges in the 21st century.

Acknowledgements

Funding Source: The study was financially supported by the Montenegrin Ministry of Science, Contract No. 1366 /2012

Conflict of Interest

The authors declare that there is no conflict of interest.

Received: 23 April 2020 | **Accepted:** 15 June 2020 | **Published:** 01 February 2021

References

Active Healthy Kids Australia, Physical Literacy: Do Our Kids Have All the Tools? Report Card on Physical Activity for Children and Young People (2016). *Active Healthy Kids, Adelaide, Australia.* Retrieved 03/01/2020, from https://www.activehealthykidsaustralia.com.au/siteassets/documents/ahka-2016-long_form-report-card.pdf

Bacil, E. D., Mazzardo Júnior, O., Rech, C. R., Legnani, R. F., & de Campos, W. (2015). Atividade física e maturação biológica: uma revisão sistemática [Physical activity and biological maturation: a systematic review]. *Revista paulista de pediatria: orgao oficial da Sociedade de Pediatria de Sao Paulo*, *33*(1), 114–121. doi: 10.1016/j.rpped.2014.11.003

Centers for Disease Control and Prevention (2018). Defining Childhood Obesity. BMI for Children and Teens. Retrieved 04/01/2020, from www.cdc.gov/obesity/childhood/defining.html

Chen, W., Hammond-Bennett, A., Hypnar, A., & Mason, S. (2018). Health – related physical fitness and physical activity in elementary school students. *BMC public health*, *18*(1), 195. doi: 10.1186/s12889-018-5107-4

Chung, A. E., Skinner, A. C., Steiner, M. J., & Perrin, E. M. (2012). Physical activity and BMI in a nationally representative sample of children and adolescents. *Clinical pediatrics*, *51*(2), 122–129. doi: 10.1177/0009922811417291

Cumming, S. P., Standage, M., Gillison, F. B., Dompier, T. P., & Malina, R. M. (2009). Biological maturity status, body size, and exercise behaviour in British youth: a pilot study. *Journal of Sports Sciences*, *27*(7), 677-86. doi: 10.1080/02640410902725590

Dumith, S. C., Gigante, D. P., Domingues, M. R., & Kohl, H. W., 3rd (2011). Physical activity change during adolescence: a systematic review and a pooled analysis. *International journal of epidemiology*, *40*(3), 685–698. https://doi.org/10.1093/ije/dyq272

Dwyer, G., Baur, L., Higgs, J., & Hardy, L. (2009). Promoting children's health and well-being: broadening the therapy perspective. *Physical and Occupational Therapy in Pediatrics, 29*(1), 27–43. doi: 10.1080/01942630802574825

Eime, R. M., Young, J. A., Harvey, J. T., Charity, M. J., & Payne, W. R. (2013). A systematic review of the psychological and social benefits of participation in sport for children and adolescents: informing development of a conceptual model of health through sport. *The International Journal of Behavioral Nutrition And Physical Activity*, *10*, 98. doi:10.1186/1479-5868-10-98

Erlandson, M. C., Sherar, L. B., Mosewich, A. D., Kowalski, K.C., Bailey, D. A., & Baxter-Jones, A.D. (2011). Does controlling for biological maturity improve physical activity tracking? *Medicine & Science in Sports & Exercise, 43*(5), 800-807. doi: 10.1249/MSS.0b013e3181ffee8a

Finger, J. D., Varnaccia, G., Borrmann, A., Lange, C., & Mensink, G. B. M. (2018). Physical activity among children and adolescents in Germany, Results of the cross-sectional KiGGS Wave 2 study and trends. *Journal of Health Monitoring*, *3*(1), 23-30. doi: 10.17886/RKI-GBE-2018-023

Janssen, I., Katzmarzyk, P. T., Boyce, W. F., Vereecken, C., Mulvihill, C., Roberts, C., Currie, C., & Pickett, W. (2005). Health behaviour in school-aged children obesity working group: comparison of overweight and obesity prevalence in school-aged youth from 34 countries and their relationships with physical activity and dietary patterns. *Obesity Reviews*, *6*(2), 123–132. doi: 10.1111/j.1467-789X.2005.00176.x

Johnson, J. A., & Johnson, A. M. (2015). Urban-rural differences in childhood and adolescent obesity in the United States: a systematic review and meta-analysis. *Childhood Obesity*, *11*(3), 233-241. doi: 10.1089/chi.2014.0085

Kelishadi, R., Ardalan, G., Gheiratmand, R., Gouya, M. M., Razaghi, E. M., Delavari, A., Majdzadeh, R., Heshmat, R., Motaghian, M., Barekati, H., Mahmoud-Arabi, M. S., Riazi, M. M., & CASPIAN Study Group (2007). Association of physical activity and dietary behaviours in relation to the body mass index in a national sample of Iranian children and adolescents: CASPIAN Study. *Bulletin of the World Health Organization*, *85*(1), 19–26. doi: 10.2471/BLT.06.030783

Kerr J., Sallis, J., Rosenberg, D. E., Grregory, N., Saelens, B., & Durant, N. (2008). USA. Active living research. Tools and Measures. Active where? Surveys. Retrieved 03/28/2020, from https://activelivingresearch.org/sites/activelivingresearch.org/files/ActiveWhere_parent_adolescent_survey.pdf

Koulouvaris, P., Tsolakis, C., Tsekouras, Y. E., Donti, O., & Papagelopoulos, P. J. (2018). Obesity and physical fitness indices of children aged 5-12 years living on remote and isolated islands. *Rural and Remote Health, 18*(2), 4425. doi: 10.22605/RRH442

Liu, Z., Xu, H. M., Wen, L. M., Peng, Y. Z., Lin, L. Z., Zhou, S., Li, W. H., & Wang, H. J. (2019). A systematic review and meta-analysis of the overall effects of school-based obesity prevention interventions and effect differences by intervention components. *The international journal of behavioral nutrition and physical activity*, *16*(1), 95. doi: 10.1186/s12966-019-0848-8

Martinovic, M., Belojevic, G., Evans, G.W, Lausevic, D., Asanin, B., Samardzic, M., Terzic, N., Pantovic, S., Jaksic, M., & Boljevic, J. (2015). Prevalence of and contributing factors for overweight and obesity among Montenegrin schoolchildren. *European Journal of Public Health*, *25*(5), 833-9. doi: 10.1093/eurpub/ckv071

McCrorie, P., Mitchell, R., Macdonald, L., Jones, A., Coombes, E., Schipperijn, J., & Ellaway, A. (2020). The relationship between living in urban and rural areas of Scotland and children's physical activity and sedentary levels: a country-wide cross-sectional analysis. *BMC Public Health*, *20*(1), 304. doi: 10.1186/s12889-020-8311-y

Mead, E., Brown, T., Rees, K., Azevedo, L. B., Whittaker, V., Jones, D., Olajide, J., Mainardi, G. M., Corpeleijn, E., O'Malley, C., Beardsmore, E., Al-Khudairy, L., Baur, L., Metzendorf, M. I., Demaio, A., & Ells, L. J. (2017). Diet, physical activity and behavioural interventions for the treatment of overweight or obese children from the age of 6 to 11 years. *The Cochrane database of systematic reviews*, *6*(6), CD012651. doi: 10.1002/14651858.CD012651

Morton, K. L., Atkin, A. J., Corder, K., Suhrcke, M., & van Sluijs, E. M. (2016). The school environment and adolescent physical activity and sedentary behaviour: a mixed-studies systematic review. *Obesity reviews: an official journal of the International Association for the Study of Obesity*, *17*(2), 142–158. doi: 10.1111/obr.12352

Must, A., & Anderson, S. E. (2006). Body mass index in children and adolescents: consideration for population-based applications. *International Journal of Obesity*, *30*, 590-594. doi: 10.1038/sj.ijo.0803300

Puyau, M. R., Adolph, A. L., Vohra, F. A. & Butte, N. F. (2002). Validation and Calibration of Physical Activity Monitors in Children. *Obesity Research*, *10*(3), 150-157. doi:10.1038/oby.2002.24

Sherar, L. B., Cumming, S. P., Eisenmann, J. C., Baxter-Jones A. D., & Malina, R. M. (2010). Adolescent biological maturity and physical activity: biology meets behavior. *Pediatric Exercise Science*, *22*(3), 332-349. doi: 10.1123/pes.22.3.332

Spinelli, A., Buoncristiano, M., Kovacs, V. A., Yngve, A., Spiroski, I., … Breda, J. (2019). Prevalence of Severe Obesity among Primary School Children in 21 European Countries. *Obesity Facts*, *12*(2), 244-258. doi: 10.1159/000500436

Tambalis, K. D., Panagiotakos, D. B., Kavouras, S. A., Papoutsakis, S., & Sidossis, L. S. (2013). Higher prevalence of obesity in Greek children living in rural areas despite increased levels of physical activity. *Journal of paediatrics and child health*, *49*(9), 769–774. doi: 10.1111/jpc.12253

Telford, R. M., Telford, R. D., Olive, L. S., Cochrane, T., & Davey, R. (2016). Why Are Girls Less Physically Active than Boys? Findings from the LOOK Longitudinal Study. *PloS one*, *11*(3), e0150041. doi: 10.1371/journal.

pone.0150041
U.S. Department of Health and Human Services (2018). *Physical Activity Guidelines for Americans, 2nd edition*. Washington, DC: U.S. Department of Health and Human Services
World Health Organization (2019). Commission on Ending Childhood Obesity. Facts and figures on childhood obesity. Retrieved 03/10, 2020, from https://www.who.int/end-childhood-obesity/facts/en/
World Health Organization (2020). Obesity and Overweight. Retrieved 03/10, 2020, from https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight

DOI 10.26773/smj.210215

ORIGINAL SCIENTIFIC PAPER

The Relationship between Jump Ability and Athletic Performance in Athletic Throwers

Yuta Takanashi[1]

[1]Juntendo University, School of Health and Sports Science, Chiba, Japan

Abstract

The purpose of this study was to examine the relationship between jump ability and athletic performance of athletic throwers based on data taken over two years. The data of 24 1st-year and 2nd-year male university throwers was compiled to examine the relationship regarding athletic performance. In summary, the three events of standing long jump (SLJ), squat jump (SJ), and counter-movement jump (CMJ) were always in a positive correlation with athletic performance in the two-year measurement. Next, SJ was most relevant to the athletic performance of the five jump measurement items. Standing triple jump (STJ) and rebound jump (RJ) did not improve in two years, and no association with the athletic performance was seen. These results suggest that simple explosive exercises, such as SLJ, SJ, and CMJ, are effective for evaluating the physical fitness of throwers. The vertical jump capability is particularly useful for evaluating athletic performance. The innovation of this study is found in SJ, which exerts power from a stationary state, and could be significant in optimizing athletic performance, which can be enhanced through modified training practices that incorporate SJ.

Keywords: *Throwers, Jump ability, performance, male, vertical jump*

Introduction

There is much evidence of the relationship between athletic performance and jump ability in athletic throwers (Takanashi, Aoki, Komura, Yonamoto, & Kaneko, 2009; Hatakeyama, Takanashi, & Sasaki, 2011; Maeda, Ohyama, Hirose, & Ogata, 2018; Aoki, Yoshimitsu, Kazuhiko, Kazunori, & Hisashi, 2015; Victor & Artur, 2003; Zaras, Stasinaki, Arnaoutis, & Terzis, 2016). Two types of measurement events, horizontal and vertical, are used to measure jump abilities. Horizontal jumping events often use standing long jumps and standing triple jumps, which are known to have a positive correlation with athletic performance (Takanashi et al., 2009; Hatakeyama et al., 2011; Maeda et al., 2018). In contrast, vertical jump types include a jump without a counter-movement (squat jump) and a jump using a counter movement (counter-movement jump). In addition, the event at which a person bounces off the ground multiple times is referred to as a rebound jump. Jump events to the vertical also have reported a positive correlation with athletic performance (Tauchi, Yoon, Kuriyama, & Takamatsu, 2002). Despite a good example of the vertical jump data shown of the world's top athlete in the shot put (Babbitt & Hoffa, 2019), there are few reports of vertical jumps overall, which may be attributed to the need of a specific device, such as a force plate or a matte switch.

There is a positive correlation between physical fitness and athletic performance, which require instantaneous power for movements such as jump ability. This is easy to predict, as the throwing distance is almost entirely determined Juby the velocity at the time of release (Gregor, Whiting, & McCoy, 1985; Dapena, 1984; Hunter & Kiggore, 2003; Murakami et al., 2006). However, the evidence for the relationship between jump ability and athletic performance simply examines the relationship between temporary physical fitness and performance. Few examples mention the change of the performance with the longitudinal change of the jump ability, other than the report by Babbit and Hoffa (2019), which shows an example of a longitudinal report of the physical strength and performance

Correspondence:

Y. Takanashi
Juntendo University, School of Health and Sports Science, Department of Athletics Field Laboratory, Hirakagakuendai 1-1 Inzai City, Chiba, Japan
Email: ytakana@juntendo.ac.jp

of one of the world's top shot putters. It is essential to ensure that the improvement of jump ability also improves athletic performance. It helps to assess the appropriateness of training in practice and to plan training.

In addition, various events, such as horizontal jumping, vertical jumping, and the presence or absence of counter-movement, have been used to study the relationship between jump ability and performance. Some of these jump ability measurement events have been treated as one jump ability without distinction. However, the physical strength reflected by the characteristics of the measurement event should be different. To date, there is no evidence to measure multiple jump ability. Therefore, this study measured the jump ability of male athletic throwers by multiple measurement severity and examined the relationship between athletic performances.

Methods

Subjects

This study aimed to measure the jump ability of 24 male university student-athletic throwers, the data for which was to be collected over the course of two years. The group consists of 2 shot putters, 10 discus throwers, 7 hammer throwers, and 5 javelin throwers. The athletic performance was scored at the Scoring Table of the International Association of Athletics Federations (IAAF). Characteristics of the subjects are as shown in Table 1.

Table 1. Characteristics of Subjects (1st year)

variable	Mean±Standard Deviation
Age	18.4±0.7
Body Height (cm)	177.17±5.28
Body Mass (kg)	88.60±9.70
IAAF Score	753.96±57.64

Legend: IAAF Score - Athletic performance scored at the Scoring Table of the International Association of Athletics Federations

This study was approved by the ethics committee of the Juntendo University School of Health and Sports Science (No.31-91). Potential candidates were given a verbal or written explanation of the study objectives, and those who gave written, informed consent to participate were enrolled. The data was anonymized in advance to third parties who were not related to this study. Therefore, the research was carried out in situations in which it was impossible to identify individuals.

Measurement data

The data in this study were two measurements of the subject's 1st and 2nd year between 2010-2018 was used. All measurements were controlled by the same supervisor.

Standing Long Jump

The operating image of the standing long jump (SLJ) is shown in Figure 1 (a). The legs were set to shoulder width, and the jump was made by using the recoil of the arms and the legs. The subjects were instructed to try to jump as far as possible.

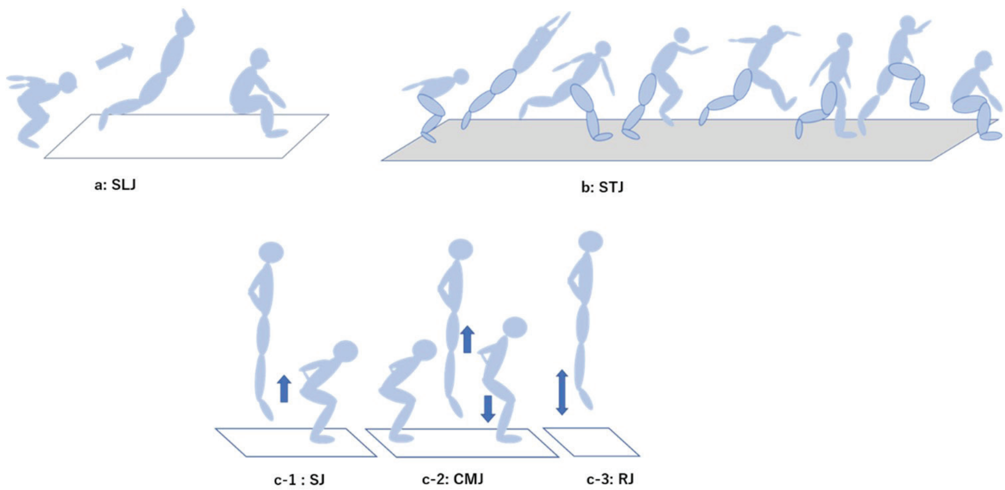


FIGURE 1. The illustration of the method of the jump test - Standing long jump (SLJ), Standing triple jump (STJ), Squat jump (SJ), Counter-movement jump (CMJ), Rebound jump (RJ)

Standing Triple Jump

The image of the standing triple jump (STJ) is shown in Figure 1 (b). The legs were set to shoulder width, and the recoil of the arms and legs were used to make the jump in three strides. The subjects were instructed to make an effort to land as far as possible.

Squat Jump

The squat jump (SJ) was measured using a mat switch (DKH multi-jump tester, Tokyo, Japan). The mat switch is activated by pressure. The measurement image is shown in Figure 1 (c-1). The angle of the knee joint was set at 90 degrees, and the jump was made without using recoil. The jump height was calculated from the time it took to land from the departure at the time of jumping.

Counter Movement Jump

The counter-movement jump (CMJ) was measured using a mat switch. The measurement image is shown in Figure 1 (c-2). The subjects held their hands on their hips and leapt using recoil. The jump height was calculated from the time it took to land from the departure at the time of jumping.

Rebound Jump Index

The rebound jump index (RJ-Index) was measured using a mat switch. Five consecutive jumps were carried out on the mat. The subjects were instructed to jump as high as possible and keep the contact time short between the jumps (Figure 1, c-3). Of the five jumps, the highest value was adopted as the measured value. This index is a figure that excludes the jumping height by the installation time.

Data Analysis

A comparison of the measurements of 1st and 2nd-year students and the difference in the rate of change were made using repeated measured t-test. The collected data were investigated using Pearson's accumulation correlation coefficient to investigate the association with the athletic performance for each year. The significance level was set at less than 5%.

Results

Athletic Performance

The results are shown in Table 2, in which the mean score of the subjects in this study was 753.96±57.64 points, which is the advanced level that can compete in national competitions in Japan. The mean IAAF Score at the time of the 1st year was 753.96±57.64, which advanced to an average score of 814.50±50.27 at the time of the 2nd year. There was a significant difference in the value of this pair ($p<0.001$). In other words, the score of all 24 athletes improved.

Table 2. Results of all measurement types

	1st year Mean±SD	2nd year Mean±SD	1st vs 2nd	% Change	Correlation between IAAF Score of % Change
IAAF Score	753.96±57.64	814.50±50.27	***	108.23±4.47***	
SLJ (m)	2.72±0.17	2.79±0.16	**	102.59±3.51**	0.305
STJ (m)	7.90±0.62	7.96±0.61		100.88±2.61	-0.064
SJ (cm)	39.47±5.30	40.93±4.89	**	104.01±5.43**	0.437**
CMJ (cm)	46.42±7.06	47.92±7.42	**	103.30±4.44**	0.221
RJ Index	2.08±0.35	1.98±0.40		95.26±12.93	0.142

Legend: * - $p<0.05$; ** - $p<0.01$; *** - $p<0.001$; 1st vs 2nd - paired t-test at 1st year and 2nd year; %Change - Change of 100% between 1st and 2nd year; SLJ - Standing long jump; STJ - Standing triple jump; SJ - Squat jump; CMJ - Counter-movement jump; RJ Index - Rebound jump index

Standing long jump (SLJ)

The results are shown in Table 2 Standing long jump was 2.72±0.17 m at the time of the 1st year, 2.79±0.16m at the time of the 2nd year. There was a significant difference in the value of this pair ($p<0.01$). The association with athletic performance was $r=0.411$ (Table 3) at the time of the 1st year ($p<0.05$), $r=0.408$ (Table 4) at the time of the 2nd year ($p<0.05$).

Standing triple jump (STJ)

The results are shown in Table 2. The record was 7.90±0.62m at the time of the 1st year, 7.96±0.61 m at the time of the 2nd year for standing triple jump. Furthermore, the association with athletic performance was $r=0.245$ (Table 3; ns) at the time of the 1st year, $r=0.373$ (Table 4; ns) at the time of the 2nd year.

Squat jump (SJ)

The values at the time of the 1st year were 39.47±5.30 cm, 40.93±4.89 cm at the time of the 2nd year for Squat jump. There was a significant difference in the value of this pair ($p<0.01$). The association with athletic performance was $r=0.528$ (Table 3; $p<0.01$) at the time of the 1st year, $r=0.582$ (Table 4) at the time of the 2nd year ($p<0.01$) (Figure 2).

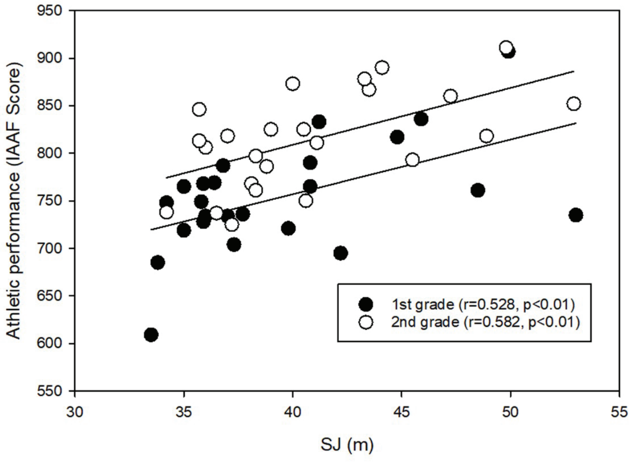


FIGURE 2. The Correlation between Athletic performance and Squat jump (SJ: Squat jump)

Counter movement jump (CMJ)

The values for Counter movement jump were 46.42±7.06 cm at the time of the 1st year, 47.92±7.42 cm at the time of the 2nd year. There was a significant difference in the value of this pair ($p<0.01$). The association with athletics performance was r=0.538 (Table 3) at the time of the 1st year ($p<0.01$), r =0.511 (Table 4) at the time of the 2nd year ($p<0.05$).

RJ-Index

The RJ-Index showed values at 2.08±0.35 at the time of the 1st year, 1.98±0.40 at the time of the 2nd year. There was a relationship between the athletic performance of r=0.319 (Table 3; ns) at the time of the 1st year, r=0.403 (Table 4; ns) at the time of the 2nd year.

Between-measurement items

The relationship between the measurements of each grade and athletic performance is shown in Tables 3 and 4.

Table 3. Relationship between measurement types in the 1st year

	SLJ	STJ	SJ	CMJ	RJ
IAAF Score	0.411*	0.245	0.528**	0.538**	0.319
SLJ		0.374	0.759***	0.831***	0.560**-
STJ			0.374	0.541**	0.369
SJ				0.867***	0.454*
CMJ					0.534**

The three SLJ, SJ, and CMJ events had a significant positive correlation with each other in two-year measurements.

Table 4. Relationship between measurement types in the 2nd year

	SLJ	STJ	SJ	CMJ	RJ
IAAF Score	0.408*	0.373	0.582**	0.511*	0.403
SLJ		0.274	0.683***	0.781***	0.326
STJ			0.513*	0.434*	0.222
SJ				0.849***	0.474*
CMJ					0.59**

The combination with the highest correlation coefficient was SJ and CMJ (the 1st year: r=0.867, the 2nd year: r=0.849). In contrast, RJ was significantly positively correlated between SJ and CMJ in two years. However, RJ and STJ showed no significant correlation in two years.

Correlation of rate of change

We investigated the correlation between the rate of change as a reference for verifying the relationship between athletic performance and measurement items. As a result, SLJ (r=0.305, ns), STJ (r=-0.064, ns), CMJ (r=0.221, ns), RJ (r=0.142, ns) was not significantly related to Athletic performance. In contrast, SJ showed a significant positive correlation with athletic performance (r= 0.437, $p<0.01$).

Discussion

The results of this study, showing a significant positive correlation between SLJ, SJ, and CMJ and athletic performance, are indeed consistent with previous reports establishing the relationship between jump ability and athletic performance (Takanashi et al., 2009; Hatakeyama et al., 2011; Maeda et al., 2018; Aoki et al., 2015; Victor & Artur, 2003; Zaras et al., 2016).

Prior to their training intervention, the subjects' performance level maintained a mediocre status that could nonetheless compete in the nationwide competition in Japan, but in one year it has improved to a high level to finish within 8th place in the same competition. For this reason, the measurement of jump ability reflects the athletic performance of the thrower from the middle class to the high class. Previous studies have evaluated the same explosive capabilities, both horizontally and vertically. However, the direction and type of jump are important issues that have not been thoroughly reported.

The best correlation between these jump events and athletic performance is seen in SJ at the 2nd year (r=0.582), followed by CMJ at the 1st year (r=0.538). In particular, SJ maintained a 1% level of relevance with athletic performance in both the 1st year and the 2nd year. All results were strongly correlated than any of the horizontal values. In other words, the jumping power of athletic throwers is best evaluated in the vertical plane. It is difficult to clarify why this is the case for only this study. However, historical evidence has reported that SLJ, which is a horizontal jump, has little intervention in the muscle group of the knee (Toriumi, Amano, & Terasawa, 1988). By analysing vertical jump ability, it is possible to evaluate the relevant jumping force of the knee muscle group. This is because that group is important for the thrower (Bourdin et al., 2010). In addition, it may be possible to predict from the operation of the throwing motion. For example, it has been reported that the distance of the shot put has a greater influence on the vertical force than the horizontal direction (Kaneko et al., 1998). This is believed to contribute to lifting the legs and transmitting ground reaction forces to the shot during the release phase of the movement. The results of this study also showed a significant positive correlation between the three jumps' measurements other than STJ and RJ, which had similar results for all measurements over the two years. This is to say that athletic performance also improved with jump ability, starting at 753.96±58.88 in the first grade and rising to 814.50±50.27 by the second year. In the field of practice, avoiding going too far in the projection direction is often advised. In other words, in order to benefit from ground reaction force, it is thought that it is important to exert force in the vertical downward direction, thus contributing to the significance of the results.

It is interesting that SJ was the most relevant event to athletic performance, given it is the only one of the five measurement stakes to require an explosive jump from the stationary state. SJ's best reflection of athletic performance suggests that it is an important factor for the thrower. As the vertical jumping events, SJ and CMJ, are highly correlated with athletic performance (the 1st year: r=0.867, the 2nd year: r=0.849), which may lead to improved instantaneous power, including technical elements, such as CMJ, by improving simple, instantaneous power like SJ. Furthermore, as shown in Table 2 in this study, the significant positive correlation between athletic performance and the rate of change in SJ ($r=0.437$, $p<0.01$) also increases the likelihood that SJ is important.

In contrast, there was no significant association between RJ and athletic performance in any of the two-year studies, in contrast to the results of a report by Tauchi et al. (2002). Of the five jump events in this study, RJ is the event at which the highest strength stretch shorting cycle (SSC) was required. RJ is a high-strength SSC, where the movement characteristics are different from the SLJ and STJ commonly used (Zushi, Takamatsu, & Kotoh, 1993). Therefore, RJ showed a different result than SJ or CMJ. There is evidence when the javelin thrower is better than the other throwers. While this study contained only five javelin throwers, it would be prudent to consider more athletes of the same event and more of different events in future studies.

Furthermore, RJ and STJ are similar in that they repeat the bounce. However, there was no significant correlation between the pair. STJ may differ from the fact that the first step does not use a high-strength SSC and that the magnitude of the stride affects it. While STJ continually rose in two years, despite lacking significance, RJ did not as it may be a special measurement item. In this study, it was not related to other jump events, and it was not possible to improve it by training as it originally measures the ability of the tendons inherent in the body. In addition, weight increase may stagnate the value of RJ, but this is expected. Nonetheless, RJ does not need to be excluded just because it is not valid for evaluation since it may be an important training exercise to maximize the strength of the athletes' tendons.

Given these results, it can be stated that not only the direction of the jumping force but also the motor characteristics influenced this result. SLJ is an explosive exercise, having the same as the motor characteristics as SJ and CMJ. In contrast, STJ and RJ, which did not have a significant positive correlation with athletic performance, are both continuous. They also have something in common to use SSC for tendons. They are not events that measure only the ability to exert simple power as they measure the technique, as well. For these reasons, a simple explosive jump event may be suitable for the physical fitness evaluation of the athlete at the level of transition from intermediate to advanced.

As mentioned earlier, this study examined five jump events, but all events have different characteristics. STJ requires techniques to link landings to the next jump and the movement of the centre of gravity. SJ requires an explosion from a stationary state. The CMJ requires vertical explosion using recoil action. RJ requires a high-strength SSC and had no significant association with athletic performance but may be necessary for training. On-site coaches and athletes should, therefore, understand and evaluate these characteristics.

These results suggest that simple explosive exercises such as SLJ, SJ, and CMJ are effective for evaluating the physical fitness of throwers. The vertical jump capability is particularly useful for evaluating athletic performance. The innovation of this study is found in SJ, which exerts power from a stationary state, and could be important in optimizing athletic performance, which can be enhanced through modified training practices that incorporate SJ. In contrast, STJ and RJ, which do not have a significant association with athletic performance, may not be reliable as a physical fitness assessment event, but we consider them important for training, nonetheless.

Acknowledgements
There are no acknowledgements.

Conflict of Interest
The authors declare the absence of conflict of interest.

Received: 10 April 2020 | **Accepted:** 03 June 2020 | **Published:** 01 February 2021

References

Aoki, K., Khomura, Y., Sakuma, K., Koshikawa, K., & Naitoh, H. (2015). Relationships between Field Tests of Power and Athletic Performance in Track and Field Athletes Specializing in Power Events. *International Journal of Sports Science & Coaching, 10*, 133-144.

Babbitt, D., & Hoffa, R. (2019). A Longitudinal Examination of the Throwing Career of Reese Hoffa. *New Studies in Athletics, 31*, 29-37.

Bourdin, M., Rambaud, O., Dorel, S., Lacour, J. R., Moyen, B., & Rahmani, A. (2010). Throwing Performance is Associated with Muscular Power. *Int J Sports Med, 31*, 505-510.

Gregor, R. J., Whiting, W. C., & McCoy, R. W. (1985). Kinetic analysis of Olympic discus throwers. *International Journal of Sport Biomechanics, 1*, 131-138.

Dapena, J. (1984). The pattern of hammer head speed during a hammer throw and influence of gravity on its fluctuation. *Journal of Biomechanics, 17*, 553-339.

Hatakeyama, S., Takanashi, Y., & Sasaki, D. (2011). An investigation into characteristics of physical fitness in discus throwers (In Japanese with English abstract). *Japanese Journal of Studies in Athletics, 4*, 17-26.

Hunter, I., & Kiggore, G. (2003). Release velocity and angle in men's and women's hammer throw. *Track Coach, 162*(winter), 5180-5181.

Kaneko, K., Sugawara, S., Katamoto, S., Suganami, M., Hirose, N., &Nakamura, M. (1998). The relationship between subjective and objective characteristics of technique in shot-putting from viewpoints of coaching (In Japanese with English abstract). *Journal of Health and Sports science Juntendo, 2*, 44-53.

Maeda, K., Ohyama, B. K., Hirose, K., & Ogata, M. (2018). Relationships between throwing distance and parameters about morphology and physical strength in male discus throw. Estimating physical strength requirement corresponding to throwing distance. *J Sports Coaching Studies, 31*, 175-184.

Murakami, M., Tanabe, S., Ishikawa, M., Isolehto, J., Komi, P. V., & Ito, A. (2006). Biomechanical analysis of the javelin at the 2005 IAAF World Championships in Athletics. *New Studies in Athletics, 21*, 67-80.

Terzis, G., Karampatsos, G., & Georgiadis, G. (2007). Neuromuscular control and performance in shot-put athletes. *J Sports Med Phys Fitness, 47*, 284-290.

Takanashi, Y., Chinen, Y., & Hatakeyama, S. (2019). Whole-Body Vibration Training improves the balance ability and leg strength of athletic throwers. *J Sports Med Phys Fitness, 59*, 1110-1118.

Takanashi, Y., Aoki, K., Komura, Y., Yonamoto, M., & Kaneko, K. (2009). The effectiveness of the evaluation of athletic capability by a field-test in female college throwers (In Japanese with English abstract). *Japanese Journal of Studies in Athletics, 79*, 30-38.

Tauchi, K., Yoon, S., Kuriyama, Y., & Takamatsu, K. (2002). Characteristics of physical fitness for javelin throwers focusing on the ability to achieve ballistic stretch-shortening cycle movement of the lower limbs (In Japanese with English abstract). *Jpn Society Ph Edu, 47*, 569-577.

Toriumi, K., Amano, Y., & Terasawa, K. (1988). The characteristics of the power exerted by each joint during take-off phase of standing long jump -compairing with vertical jump (In Japanese with English abstract). *Departmental Bulletin Paper of Chukyo University, 30*, 23-33.

Victor, M. R., & Artur, J. F. (2003). The validity of general and specific strength tests to predict the Shot Put performance – a pilot study. *International Journal of Performance Analysis in Sport, 3*, 112-120.
Zaras, N., Stasinaki, A. N., Arnaoutis, G., & Terzis, G. (2016). Predicting Throwing Performance with Field Tests. *New Studies in Athletics, 31*, 9-19.
Zushi, K., Takamatsu, K., & Kotoh, T. (1993). The specificity of leg strength and power in several sport athletes (In Japanese with English abstract). *Japan J. Phys. Educ, 38*, 265-278.

DOI 10.26773/smj.210217

ORIGINAL SCIENTIFIC PAPER

The Effect of Social Capital Dimensions on the Knowledge-Sharing Intention of Physical Education Teachers

Javad Shahlaei Bagheri[1], Akbar Jaberi[2], Farzaneh Mazloomi Soveini[3] and Habib Honari[1]

[1]Allameh Tabataba'i University, Department of Sport Management, Tehran, Iran, [2]Shahid Bahonar University of Kerman, Department of Sport Management, Kerman, Iran, [3]Allameh Tabataba'i University, Department of Sport Management, Tehran, Iran

Abstract

Social capital and knowledge sharing can be defined as the most important asset of educational organizations. The current study aims to assess the effect of social capital dimensions on the knowledge-sharing intention of physical education teachers in Fars province in Iran. To realize this research, a field study was conducted on 268 physical education teachers. Analysis of a moment structures (AMOS) version 18 and statistical package for the social sciences (SPSS) version 18 were applied for data analysis and hypotheses testing to fulfil the research objectives. To measure the validity and fitness of the model, Structural Equations Modelling (SEM) has been applied. The findings indicate that the social capital dimensions had a significant and positive effect on knowledge-sharing intention among physical education teachers. The findings also highlight the significant role of social capital elements in predicting physical education teachers' intention to participate in the process of knowledge sharing.

Keywords: *social capital, knowledge sharing, physical education, teachers*

Introduction

The success of organizations is not only dependent on physical resources, but it has a close relationship with acquiring knowledge as well as effective participation of employees in the process of organizational learning. Efficient employees are the most strategic factors for organizational success. Considering issues such as knowledge sharing and social capital can provide educational organizations with dynamic performance. Teachers and the education system in each community play an essential role in creating and increasing social capital as well as knowledge sharing. As the construction of educational systems has always been criticized for its lack of innovative capacities, or for its inability to employ a more efficient education process (Agapiou, 2002), examining both knowledge management mechanisms and their enablers can provide education systems the ability to cope with these challenges, which require schools and educational sectors to expand their activities related to knowledge management. In this regard, public schools can promote the exchange of knowledge as one of the most critical intangible forms of capital.

Social capital can be defined as a proper theoretical framework to explain knowledge-sharing mechanisms in educational organizations. As a highly debated concept, it is a central construct in contemporary sociology (Coleman, 1988). Social capital plays a pivotal role in mediating human capital and organizational capital and refers to several collective emotional, cognitive and communicative skills and resources that are vital for enhancing the existing know-how of an organization (Styhre, 2008). Without social capital,

Correspondence:

J. Shahlaei Bagheri
Allameh Tabataba'i University, Department of Sport Management, Dehkadeh Olympic, Iran, Tehran
E-mail: javadshahlaee@gmail.com

the potentials of human and organizational capital cannot be exploited completely (Subramaniam & Youndt, 2005). According to Styhre (2008), the critical social practice that facilitates knowledge sharing can be considered to be the most critical way to convey learning. In organizations with high levels of social capital, co-workers share their insights and know-how. In such organizations, knowledge is not an individual property; instead, it is collectively mobilized and used in everyday practice.

Social capital explains how social resources create positive experiences at work and lead to useful results (Nahapiet & Ghoshal, 1998). It facilitates information exchange in organizations (Lazega & Pattison, 2001) and helps individuals work together effectively when they trust and identify with one another and can provide organizational advantages (Nahapiet & Ghoshal, 1998). It can facilitate the flow of information between individuals. Adler and Kwon (2002) concluded that social capital significantly contributes to organizational benefits. Nahapiet and Ghoshal (1998) also considered social capital necessary for the development and distribution of knowledge in organizations. The findings of Burt (1997) revealed that managers who had more social capital were promoted earlier on in their careers, received larger bonuses, and generally obtained a higher return on their investment in human capital (Burt, 1997).

In addition to social capital, knowledge is one of the primary sources of gaining competitive advantage in a dynamic and competitive environment (Wang & Noe, 2010). Liebowitz (2001) considered recording, sharing, applying and creating knowledge in the organization as the best means of influencing internal and external resources. The sharing of knowledge enables productivity and investment in knowledge-based resources. Knowledge sharing refers to disseminating ones' knowledge and experience to others. To develop knowledge efficiently, organizations should encourage people to be involved in knowledge contribution and knowledge-seeking cycles (Bock, Kankanhalli, & Sharma, 2006).

The ultimate goal of employee knowledge sharing is to attempt to transfer the experiences and knowledge of all individuals into assets and organizational resources to increase organizational effectiveness. Knowledge sharing is a set of behaviour that involves exchanging knowledge and information, which can provide individuals and organizations with an opportunity to create and utilize knowledge. Organizations play a critical part in persuading individuals to exchange their knowledge and experience with others (Nonaka, 1994). Close interaction and communication between people are necessary infrastructure for effective knowledge sharing. Stimulating individuals to participate in knowledge-sharing activities and the kind of social setting that facilitates knowledge sharing are essential domains for researchers and managers (Alavi & Leidner, 2001). Social capital has been used to explain why people are likely to exchange their knowledge with others (Wasko & Faraj, 2005). Understanding the different dimensions of social capital underpinning information sharing is a prerequisite for effective knowledge management.

Knowledge sharing is a fundamental tool for achieving a competitive advantage (Jackson, Chuang, Harden, & Jiang, 2006). It seems that knowledge-sharing practices with social capital in organizations can be closely related. In other words, indicators such as bilateral engagement and trust and integrity, which are part of social capital, can be primarily considered as prerequisites for knowledge-sharing behaviour. The need to identify and to explain the effects of social capital on knowledge sharing is one of the strategic requirements of organizations to move towards knowledge-based learning organizations.

Providing an appropriate platform and devising appropriate strategies can help teachers to gain more knowledge and transfer their knowledge to others effectively. The effective sharing of knowledge leads to a reduction in the costs of producing knowledge, and guarantees the dissemination of the best practices within the education systems and enables the education systems to solve the problems effectively. Based on the social capital theory, prior studies pertaining to knowledge sharing have been conducted under different sharing context, such as sharing in blogs (e.g., Chai & Kim, 2010), virtual communities (e.g., Chiu, Hsu, & Wang, 2006; Wasko & Faraj, 2005), knowledge repository systems (e.g., Lin & Huang, 2008), within organizations (e.g., Szulanski, Cappetta, & Jensen, 2004), or within teams (e.g., Majchrzak, Malhotra, & John, 2005; Staples & Webster, 2008). Social capital in the context of school teachers has not been studied to date, as the studies are mainly examining social aspects and knowledge sharing in corporate settings. The present research is one of the few studies that have been conducted to study the relationship between knowledge sharing with social capital in the field of physical education teaching.

Despite the increasing importance of knowledge sharing in education systems, few studies have been conducted to examine these concepts among physical education teachers. Social capital and knowledge sharing are of fundamental importance in increasing education efficiency, and more attention to these concepts can improve the effectiveness of physical education teachers' performance. Because social capital has been defined according to different approaches, it has also been conceptualized differently by scholars (Coleman, 1998). Contrary to other similar studies (Martínez-Ca˜nas, Sáez-Martínez & Ruiz Palomino, 2012), that operationalized social capital following the framework of Nahapiet and Ghoshal (1998) with three dimensions (the structural dimension, the cognitive dimension and the relational dimension), the authors of the present paper employed a different social capital framework including "Reliability", "Social cohesion", "Social Network and Participation", "Capacity to accept criticism", and "Social interaction". These dimensions of social capital have been found to be useful when exploring knowledge-sharing practices. This study brings critical aspects to the debate on how the combination of social dimensions supports knowledge sharing.

This study was set up to study the effect of social capital dimensions on the knowledge sharing of physical education teachers in Fars province in Iran. Conducting such studies can be critical to promoting the concepts of knowledge management in different areas related to sport and exercise teaching. In this research, based on the literature review, the impact of social capital components on the knowledge sharing of physical education teachers according to the following conceptual model (Figure 1) has been studied.

As social capital dimensions increase the exchange of knowledge, according to the literature review, it is likely that their development among physical education teachers

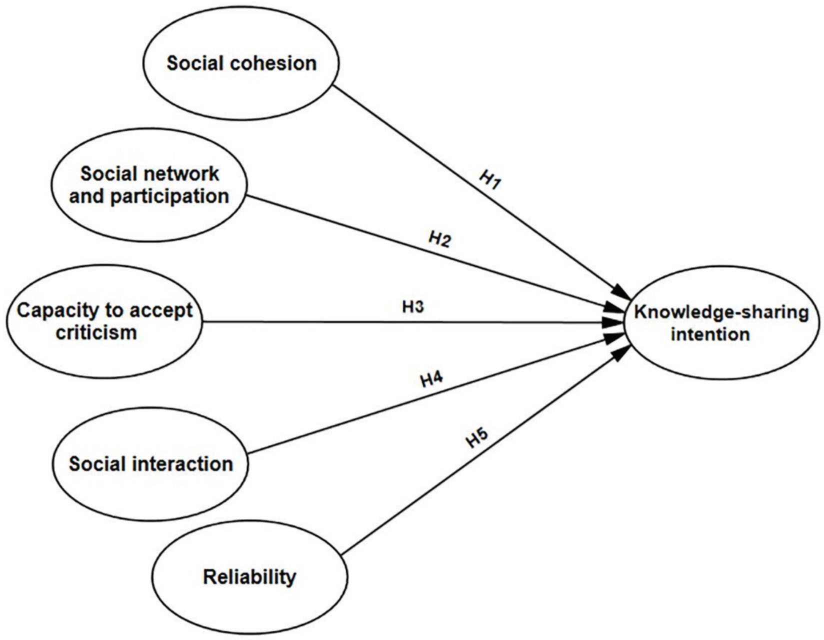


FIGURE 1: The Research Model

operates as a platform for knowledge sharing. Thus, the following hypotheses were developed in the research model. According to the research model, the hypotheses were proposed as follows:

H1. "Social cohesion" has a significant effect on "knowledge-sharing intention" among physical education teachers.

H2. "Social Network and Participation" has a significant effect on "knowledge-sharing intention" among physical education teachers.

H3. "Capacity to accept criticism" has a significant effect on "knowledge-sharing intention" among physical education teachers.

H4. "Social interaction" has a significant effect on "knowledge-sharing intention" among physical education teachers.

H5. "Reliability" has a significant effect on "knowledge-sharing intention" among physical education teachers.

Methods

A field study with a quantitative approach was conducted among physical education teachers in Fars province in Iran to realize this study. Based on a proposed equation for measuring the sample size for an SEM approach, a research sample (n=268) was selected through convenience sampling. All the respondents were physical education teachers in Fars province, Iran; 144 of the respondents (53.7%) were male. The average age was 28.0 years (standard deviation of 5.6 years); 189 of the respondents (70.5%) had up to five years of work experience.

A cover letter of explanation with detailed information about the research objectives was attached to each survey. The questionnaire took 10 to 12 minutes to complete. The data collection period took four months, from February to May 2018; 251 valid questionnaires were returned to be used in data analysis (the response rate was 93.66%). AMOS20 and SPSS18 were used for data analysis. To measure the dimensions of social capital, a researcher-developed questionnaire was used. The knowledge-sharing intention was measured using a four-item instrument adapted from Taylor and Todd's questionnaire (1995). The dimensions of social capital (Reliability, Social cohesion, Social Network and Participation, Capacity to accept criticism, Social interaction) were measured using a 24-item instrument extracted from a semi-structured interview conducted with 15 academic experts through a qualitative approach. A Likert-type seven-point response scale from "Strongly disagree" (1) to "Strongly agree" (7) was employed for data collection. To verify the validity of the questionnaires, content and face validity as well as construct validity were employed. The reliability of the questionnaire was calculated using Cronbach's alpha after a pilot study. The Cronbach's alpha coefficient was found to be 0.85, and the validity of the questionnaire was verified by using experts' point of views. Accordingly, at first, 10 copies of the first questionnaire were distributed among faculty members and specialists in the field of sports management and organizational behaviour, and they were asked to comment on the comprehensibility, modification, and deletion of items. To verify the construct validity of the questionnaire, confirmatory factor analysis was used.

The value of Cronbach's alpha coefficients (greater than 0.7), and the C.R. indexes (greater than 0.8), supported the scale reliability (Chin, 2010) (Table 1). The factor loadings were higher than the recommended threshold of 0.70, and the AVE for each construct ranged from 0.65 to 0.74 (Table 1), which were higher than the suggested threshold of 0.5 (Hair Jr, Hult, Ringle, & Sarstedt, 2016), showed proper convergent validity for all constructs.

An assessment of the measurement model was presented in Table 1 to support the scale reliability and validity (Table 1).

To measure the validity and fitness of the model, Structural Equations Modelling (SEM) has been applied. This modelling both investigates the adaptation of the data and the conceptual model to determine if it bears a sufficient fit and investigates the significance of the relationships in this fitted model.

Table 1. Results of measurement properties

Construct	Items	OL (>0.70)	α (>0.70)	CR (>0.70)	AVE (>0.50)
Social cohesion	SC1 SC2 SC3 SC4	0.89[a] 0.85[a] 0.80[a] 0.88[a]	0.82	0.83	0.75
Social network and participation	SNP1 SNP2 SNP3 SNP4 SNP5	0.85[a] 0.81[a] 0.89[a] 0.91[a] 0.86[a]	0.79	0.85	0.73
Capacity to accept criticism	CAC1 CAC2 CAC3 CAC4 CAC5	0.88[a] 0.86[a] 0.86[a] 0.85[a] 0.84[a]	0.82	0.88	0.70
Social interaction	SI1 SI2 SI3 SI4 SI5	0.88[a] 0.84[a] 0.83[a] 0.81[a] 0.85[a]	0.86	0.84	0.64
Reliability	RE1 RE2 RE3 RE4 RE5	0.82[a] 0.88[a] 0.82[a] 0.83[a] 0.81[a]	0.81	0.82	0.68
Knowledge-sharing intention	KSI1 KSI2 KSI3 KSI4	0.81[a] 0.83[a] 0.81[a] 0.86[a]	0.82	0.83	0.69

Legend: OL - Outer Loading; A - Cronbach's Alpha; CR - Composite reliability; AVE - Average variance extracted; SC - Social Cohesion; SNP - Social Network and Participation; CAC - Capacity to Accept Criticism; SI - Social Interaction; RE – Reliability; KSI - Knowledge-Sharing Intention

Results

To test the hypotheses, a structural equations model was used. Table 2 shows the fit indices of that model. The indexes of the overall fit of the model included normed chi-square, goodness-of-fit index, adjusted goodness-of-fit index, normed fit index, comparative fit index and root mean squared error. The results of the fit indices of the conceptual model have been given in Table 2.

Table 2. Fit Indices of the Model

Index	Cmin/df	GFI	AGFI	NFI	CFI	RMSEA
Study model	2.49	0.94	0.95	0.93	0.92	0.07
Recommended value	<3	>0.90	>0.90	>0.90	>0.90	<0.10

Legend: GFI - Goodness-of-fit index; AGFI - Adjusted goodness-of-fit index; NFI - Normed fit index; CFI - Comparative fit index; RMSEA - Root mean squared error

According to Table 2, the fitness indices showed a good fitness.

Critical ratio (C.R.) and p value were used to test the significance of the hypotheses. The critical ratio is computed through regression weight divided by the standard error. Based on the significance level of 0.05, C.R. should be higher than 1.96. Those values under 1.96 are not considered to be important parameters in the model. Also, the P values lower than 0.05 show a significant difference in the computed values for regression weights of zero at 0.95 of confidence level. Table 3 shows the hypotheses, regression weights, and the index

Table 3. Hypothesis-Testing Results

Path			Regression weight	C.R	Result
Social cohesion	→	knowledge-sharing intention	0.44***	7.44	Supported
Social Network and Participation	→	knowledge-sharing intention	0.59***	8.31	Supported
Capacity to accept criticism	→	knowledge-sharing intention	0.48***	9.58	Supported
Social interaction	→	knowledge-sharing intention	0.41***	8.85	Supported
Reliability	→	knowledge-sharing intention	0.51***	10.36	Supported

Legend: *** - p<0.001

of each hypothesis. Table 3 shows the hypotheses, regression weights, and the index of each hypothesis.

The findings in Table 3 showed that all dimensions of social capital had a positive and significant effect on knowledge-sharing intention among physical education teachers in Fars province.

Discussion

Education systems are often engaged with the question of how to do more with fewer resources, and one of the most critical areas in which remarkable increases in effectiveness are to be achieved is the knowledge-sharing process. This study demonstrated that social capital plays a significant role as the infrastructure of knowledge-sharing performance. Our article contributes to the literature on social capital and knowledge sharing by introducing different social capital dimensions as well as studying these concepts in the physical education school domain.

The purpose of the current study was to assess the effect of social capital dimensions on the knowledge-sharing intention of physical education teachers in Fars province. This study provides a model that examines the effects of social capital dimensions (Reliability, Social cohesion, Social Network and Participation, Capacity to accept criticism, Social interaction) on the knowledge-sharing intention of physical education teachers. The findings revealed that social capital plays a key role in explaining knowledge-sharing performance.

The results showed that the influence of Reliability, Social cohesion, Social Network and Participation, Capacity to accept criticism and Social interaction on knowledge sharing was statistically significant (As demonstrated in Table 3). Focusing on social capital and its relationship with knowledge sharing promote knowledge in the education system, especially among teachers. The results of the research are consistent with the findings of Adler and Kwon (2002). Nahapiet and Ghoshal (1998) also consider social capital necessary for the development and distribution of knowledge in organizations. Harell (2009), and Cohen and Prusak (2001) find that there was a positive relationship between social capital and the dimensions of knowledge management, which is consistent with the results of the current research. Knowledge sharing provides physical education teachers with the opportunity to interact closely with each other and to exchange their technical, expert, and experimental information. Social capital is a critical asset that can help any organization create a sustainable competitive advantage. The necessity of identifying and explaining the relationship between social capital and knowledge sharing is one of the strategic needs of organizations in achieving a knowledge-based and learning atmosphere.

According to Coleman (1998), social capital is productive and enables the achievement of certain ends. The social capital creation provides an opportunity to develop mutual understanding, to build trust and to ensure equality to foster commitment and cooperation (Cohen & Prusak, 2001). The knowledge-sharing process often takes place in collaborative settings and, therefore, the social aspects may play an important role.

To examine and understand how organizations develop, the concept of social capital should be brought into the analysis (Styhre, 2008). To reinforce social capital, a trusting atmosphere should be increased in schools and education systems. Social capital can be strengthened by encouraging communication skills among physical education teachers. Communication between management and teachers can develop social capital and finally job satisfaction among physical education teachers. Thus, management must help to provide formal as well as informal communication opportunity to facilitate knowledge-sharing processes. To develop social capital, we need to design strategies for reinforcing a culture of trust and willingness to work collectively. As a consequence, managers of education systems should carefully consider how social capital is nourished and developed at their organizations.

To manage different aspects of knowledge-sharing mechanisms, the dimensions of social capital are proper tools: Reliability, Social cohesion, Social Network and Participation, Capacity to accept criticism, and Social interaction. Our model is the initial attempt to conceptualize the effect of social capital elements on knowledge-sharing intentions in public educational sectors. The testing and verification of the model require more data which can be obtained by conducting quantitative and qualitative studies in a variety of educational systems.

The study of social capital and knowledge-sharing concepts by conducting quantitative and qualitative approaches can be considered by researchers in the field of sport education in the future. Future studies on knowledge sharing and social capital should focus on different kinds of enablers of and obstacles to knowledge sharing and various aspects of social capital in public school contexts. A complete understanding of the multidimensionality of enablers and obstacles of knowledge sharing and intangible capital in the physical education sector is highly significant and may promote educational efforts.

Acknowledgements
There are no acknowledgements.

Conflict of Interest
The authors declare that there are no conflicts of interest.

Received: 11 March 2020 | **Accepted:** 28 May 2020 | **Published:** 01 February 2021

References

Adler, P. S., & Kwon, S. W. (2002). Social capital: Prospects for a new concept. *Academy of management review*, *27*(1), 17-40. doi: 10.2307/4134367

Agapiou, A. (2002). Perceptions of gender roles and attitudes toward work among male and female operatives in the Scottish construction industry. *Construction Management & Economics*, *20*(8), 697-705.

Alavi, M., & Leidner, D. E. (2001). Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS quarterly*, 107-136. doi: 10.2307/3250961

Bock, G. W., Kankanhalli, A., & Sharma, S. (2006). Are norms enough? The role of collaborative norms in promoting organizational knowledge seeking. *European Journal of Information Systems*, *15*(4), 357-367. doi: 10.1057/palgrave.ejis.3000630

Burt, R.S. (1997). The contingent value of social capital. *Administrative Science Quarterly*, *42*, 339–65. doi: 10.2307/2393923

Chai, S., & Kim, M. (2010). What makes bloggers share knowledge? An investigation on the role of trust. *International journal of information management, 30*(5), 408-415. Doi: 10.1016/j.ijinfomgt.2010.02.005

Chin, W. W. (2010). How to write up and report PLS analyses. In Handbook of partial least squares (pp. 655-690). Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-540-32827-8_29.

Chiu, C. M., Hsu, M. H., & Wang, E. T. (2006). Understanding knowledge sharing in virtual communities: An integration of social capital and social cognitive theories. *Decision support systems, 42*(3), 1872-1888. doi:10.1016/j.dss.2006.04.001

Cohen, D.J. and Prusak, L. (2001). In good company: How social capital makes organizations work. Ubiquity, 2001(January), p.3. doi:10.1145/358974.358979

Coleman, J. S. (1988). Social capital in the creation of human capital.

American journal of sociology, 94, S95-S120. https://www.jstor.org/stable/2780243

Hair Jr, J. F., Hult, G. T. M., Ringle, C., & Sarstedt, M. (2016). A primer on partial least squares structural equation modeling (PLS-SEM). Sage Publications.

Harell, A. (2009). Equal Participation but Separate Paths?: Women's social capital and turnout. *Journal of Women, Politics & Policy, 30*(1), 1-22. doi:10.1016/j.im.2007.11.001

Inkpen, A. C., & Tsang, E. W. (2005). Social capital, networks, and knowledge transfer. *Academy of management review, 30*(1), 146-165. doi: 10.2307/20159100

Jackson, S. E., Chuang, C. H., Harden, E. E., & Jiang, Y. (2006). Toward developing human resource management systems for knowledge-intensive teamwork. In Research in personnel and human resources management (pp. 27-70). Emerald Group Publishing Limited. doi:10.101 b/~741-7301(06)2fr02-

Jones, P. D., Briffa, K. R., Osborn, T. J., Lough, J. M., Van Ommen, T. D., Vinther, B. M., ... & Schmidt, G. A. (2009). High-resolution palaeoclimatology of the last millennium: a review of current status and future prospects. *The Holocene, 19*(1), 3-49. https://doi.org/10.1177/0959683608098952

Liebowitz, J. (2001). Knowledge management and its link to artificial intelligence. *Expert systems with applications, 20*(1), 1-6. https://doi.org/10.1016/S0957-4174(00)00044-0

Lin, T. C., & Huang, C. C. (2008). Understanding knowledge management system usage antecedents: An integration of social cognitive theory and task technology fit. *Information & Management, 45*(6), 410-417. doi:10.1016/j.im.2008.06.004

Majchrzak, A., Malhotra, A., & John, R. (2005). Perceived individual collaboration know-how development through information technology–enabled contextualization: Evidence from distributed teams. *Information systems research, 16*(1), 9-27. doi: 10.1287/isre.1050.0044

Martínez-Cañas, R., Sáez-Martínez, F. J., & Ruiz-Palomino, P. (2012). Knowledge acquisition's mediation of social capital-firm innovation. *Journal of Knowledge Management, 16*(1), 61-76. doi:10.1108/13673271211198945

Nahapiet, J., & Ghoshal, S. (1998). Social capital, intellectual capital, and the organizational advantage. *Academy of management review, 23*(2), 242-266. doi:10.2307/259373

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization science, 5*(1), 14-37. https://doi.org/10.1287/orsc.5.1.14

Staples, D. S., & Webster, J. (2008). Exploring the effects of trust, task interdependence and virtualness on knowledge sharing in teams. *Information Systems Journal, 18*(6), 617-640. doi:10.1111/j.1365-2575.2007.00244.x

Styhre, A. (2008). The role of social capital in knowledge sharing: the case of a specialist rock construction company. *Construction management and economics, 26*(9), 941-951.

Subramaniam, M., & Youndt, M. A. (2005). The influence of intellectual capital on the types of innovative capabilities. *Academy of Management journal, 48*(3), 450-463. doi: 10.2307/20159670

Szulanski, G., Cappetta, R., & Jensen, R. J. (2004). When and how trustworthiness matters: Knowledge transfer and the moderating effect of causal ambiguity. *Organization science, 15*(5), 600-613. doi: 10.1287/orsc.1040.0096

Taylor, S., & Todd, P. A. (1995). Understanding information technology usage: A test of competing models. *Information systems research, 6*(2), 144-176. https://doi.org/10.1287/isre.6.2.144

Wang, S., & Noe, R. A. (2010). Knowledge sharing: A review and directions for future research. *Human resource management review, 20*(2), 115-131. doi:10.1016/j.hrmr.2009.10.001

Wasko, M. M., & Faraj, S. (2005). Why should I share? Examining social capital and knowledge contribution in electronic networks of practice. *MIS quarterly, 29*(1), 35-57. doi: 10.2307/25148667

DOI 10.26773/smj.210218

ORIGINAL SCIENTIFIC PAPER

Analysis of Physical Fitness and Physical Activity Results of Female Undergraduate and Graduate Students

Aleksander Yurevich Osipov[1,2,3], Roman Sergeevich Nagovitsyn[4], Olga Igorevna Vaganova[5], Maxim Mikhaylovich Kutepov[5], Elena Alexandrovna Chelnokova[5], Tatyana Igorevna Ratmanskaya[1] and Anna Vladimirovna Vapaeva[1]

[1]Siberian Federal University, Department of Physical Culture, Krasnoyarsk, Russia, [2]Krasnoyarsk State Medical University named after Professor V. F. Voyno-Yasenetsky, Department of Physical Culture, Krasnoyarsk, Russia, [3]Siberian Law Institute of the MIA of Russia, Department of Physical Training, Krasnoyarsk, Russia, [4]Glazov State Pedagogical Institute named after V. G. Korolenko, Department of Physical Culture and Safety Life, Glazov, Russia, [5]Minin Nizhny Novgorod State Pedagogical University, Nizhny Novgorod, Russia

Abstract

Information about the volume and intensity of the physical activity of students is collected through various methods of inquiry. Questionnaire data needs to be compared with objective criteria of the physical fitness of students. The purpose of the present research is a comparison of the International Physical Activity Questionnaire (IPAQ) data and the results of functional fitness assessment tests of female undergraduate (n=639) and graduate (n=625) students. The IPAQ data were used to determine the level of physical activity in females. Data regarding the BMI and self-perceived physical fitness of females are collected. The physical fitness level of the female students was assessed using functional fitness assessment tests. The IPAQ results show significant ($p<0.05$) differences in the total weekly volume of physical activity of females. More weekly physical activity volume was found in female graduate students. The advantage in IPAQ results is achieved by significantly ($p<0.01$) more weekly physical activity in the office job. The weekly volume of health and sports physical activity is significantly ($p<0.01$) higher in female undergraduate students. The data on the volume of regular daily movement in female groups do not differ significantly. The results of fitness testing showed an insufficient level of physical fitness of female students of both groups. BMI results of female students are normal. A significant lack of the total volume of physical activity of students of both groups in comparison with the IPAQ data of female students of some European countries was revealed. Increasing the total amount of physical activity and improving the quality of physical activity is recommended.

Keywords: *female students, physical fitness, IPAQ, fitness tests, BMI*

Introduction

Human health significantly depends on the level of physical activity (PA) and healthy nutrition (Concha-Cisternas et al., 2018). Scientists indicate that PA should be systematic and regulated by age-appropriate exercise intensity (Bergier et al., 2018). A detailed study of students' PA level is vital for assessing the health status of future social elites of society (Bergier et al., 2018). The research data suggests that many students do not meet the PA recommendations of the World Health Organization (Juškelienė & Česnavičienė, 2017). The main reasons for the lack of PA of students include a heavy study load and enthusiasm for the internet and computer games (Kudryavtsev, Kramida, & Osipov, 2016). To collect data on the daily PA level of students, scientists use a variety of survey

Correspondence:

Aleksander Osipov
Siberian Federal University, Department of Physical Culture, Avenue Free 79, 660041, Krasnoyarsk, Russia
E-mail: Ale44132272@ya.ru

methods. In recent years, the International Physical Activity Questionnaire (IPAQ) has become a common tool (Loginov, Nikolaev, Vetoshnikov, & Sagadeeva, 2015). The final results of the survey of students differ significantly. Some studies indicate a sufficient PA level of students of some universities (Mulahasanović, A. Mujanović, E. Mujanovic, Atikovic, & Maglaj, 2018). Other data indicate a significant PA deficiency in this social group (Pedisic, Rakovac, Bennie, Jurakic, & Bauman, 2014). It was found that a significant proportion of students did not comply with global recommendations for optimal PA levels during the week (Tinazci, EAlrefai, & Musa, 2019).

It was revealed that the PA level of male students is significantly higher than that of female students (Bergier et al., 2018). Female students showed lower levels of interest in regular PA and sports than male students did (Bukova, Zuskova, Szerdiová, & Kuchelová, 2017). The consequence of PA deficiency is the deterioration of health and the development of obesity in a significant proportion of female students (Osipov et al., 2018). The direct dependence between the decrease in the level of physical fitness and increase in body weight of females has been defined (Kolokoltsev & Iermakov, 2019). The PA level has been found to be significantly lower in obese females, in each type of physical effort, except light effort (Gabrys, Nowak, Michalski, Szmatlan-Gabrys, & Stanula, 2018). Lack of regular PA has an adverse impact on the level of psychological endurance of females (Şar Nuriye, Soyer, & Koç, 2018). However, there is evidence that the majority of students, particularly females, were within the healthy body weight range. At the same time, the PA level of female students was not high (Yahia, Wang, Rapley, & Dey, 2016). Female students, more frequently than male students, demonstrated lower indices of participation in PA as well as a positive phenomenon seen in the normal BMI and trace values of overweight in females, which is exactly the reverse to males (Bergier, Bergier, & Tsos, 2017).

Scientists state the need to use practical tests to study the correlation between subjective assessments and objective indicators PA level of students (Leuciuc, 2018). A widely-used self-report tool (International Physical Activity Questionnaire (IPAQ) also needs to be modified, and the data reliability needs to be improved (Frehlich, Friedenreich, Nettel-Aguirre, & McCormack, 2018). To improve the reliability of the PA structure and volume assessment, it is necessary to compare IPAQ data with the results of the physical fitness testing of students. The need to compare IPAQ data with measurements of step daily activity of students is emphasized by researchers (Marttinen, Fredrick, & Silverman, 2018; Nikolaev & Solodilov, 2016). In the Russian Federation, students' physical education (PE) scores are assessed by means of tests of the Russian Physical Culture and Sports GTO complex (Zyurin, Bobkova, Morozov, & Poliyevsky, 2018). Students take part in GTO complex tests on a voluntary basis. Many female students do not participate in the GTO complex, which does not allow for objective conclusions about the state of physical fitness. A problem of determining the total volume and quality of physical activity of a significant part of female students of Russian universities exists.

The review of scientific data identified the primary purpose of the research: comparison of IPAQ results with objective physical fitness profile indicators of Russian female students (undergraduate and graduate students).

Methods

Participants

Females participants: (n=1264): undergraduate students (n=639) and graduate students (n=625). The average age of female students was 20.36±2.19 years. The average age of female graduate students was 23.18±2.24 years. All participants gave their informed consent to take part in the studies and had no medical contraindications for PE and fitness training.

Organization and research methods

The research was based in large universities located in different regions of the Russian Federation (Krasnoyarsk Region, Nizhny Novgorod Region, and Udmurt Republic). The research was conducted over two months (May-June 2019). The PA level of females was assessed using IPAQ. The IPAQ questionnaire was supplemented with three original questions concerning body mass and height, which allowed for calculating the BMI index, as well as self-perceived physical fitness (high, good, moderate, and low). Administering the questionnaire to the students took place twice, with an interval of four weeks.

The level of physical fitness profile of the participants in the study was assessed using Functional fitness assessment tests: aerobic fitness test (one-mile run test); rest 5 minutes; upper body strength/endurance (push-up) test; rest 3 minutes; lower body strength/endurance (squat) test; rest 3 minutes; core strength/endurance (plank) test.

Statistical analysis

Analysis of the results was carried out using the IBM SPSS Statistics for Windows 20.0 (Armonk, NY: IBM Corp.). The general findings are presented as means and standard deviations (SD). The reliability and statistical significance of the results were determined using the Pearson test (Chi-square) and T-test. The level of significance was accepted $p<0.05$.

Results

The IPAQ findings are presented in the total time of PA spent (minutes). A significant number of participants had difficulty counting results at the MET (metabolic equivalent of task). Also, a more robust comparison with data of other investigators (represented in time spent - minutes) was required.

The IPAQ results show a significant ($p<0.05$) predominance of the total weekly PA (PA–total) in the female graduate students. They have significantly ($p<0.01$) higher volume of working PA (PA–job) during the week. There were no significant differences in PA–moving and PA–homework in both groups. In the volume of sports and fitness (PA–sport and fitness) a significant ($p<0.01$) prevalence of weekly PA in female undergraduate students was revealed. Most of the independent PA scores in both groups are positive scores (Good level). BMI indicators correspond to the norm in both groups of studied females. In the group of female graduate students, BMI data were significantly higher ($p<0.05$).

The findings of functional fitness assessment tests are presented: aerobic fitness test (minutes), plank test (seconds); push-up and squat tests (repetitions). The overall results of functional fitness assessment tests were found to be unsatisfactory in both groups. Female undergraduate students showed significantly ($p<0.05$) higher results in the aerobic fitness test (one-mile run test) and upper body strength/endurance (push-up) test. In other fitness tests, there were no significant differences between the groups. The main results of the IPAQ and fitness tests of females are presented in Table 1.

Table 1. The IPAQ and fitness tests results of female undergraduate and graduate students

IPAQ / Functional fitness assessment tests	Female undergraduate students (n=639)	Female graduate students (n=625)
Job PA	426.74±42.63	883.56±64.18**
PA moving	853.29±37.44	849.23±28.32
Homework PA	795.72±46.29	782.47±52.44
Sport and Fitness PA	796.61±32.45**	512.42±41.23
Total PA	2872.36±159.21	3027.68±186.17*
Self-perceived PF	Good level (65.4%)*	Good level (61.9%)
One mile run test	7.44±0.27	8.26±0.32*
Push-up test	14.43±2.51*	13.58±2.46
Squat test	52.17±4.75	51.94±4.23
Plank test	0.54±0.13	0.51±0.09
BMI	22.39±0.16	23.06±0.22*

Legend: * - p<0.05; ** - p<0.01.

The percentage of tests results of female students to standard results of the functional fitness assessment tests is presented in Figure 1.

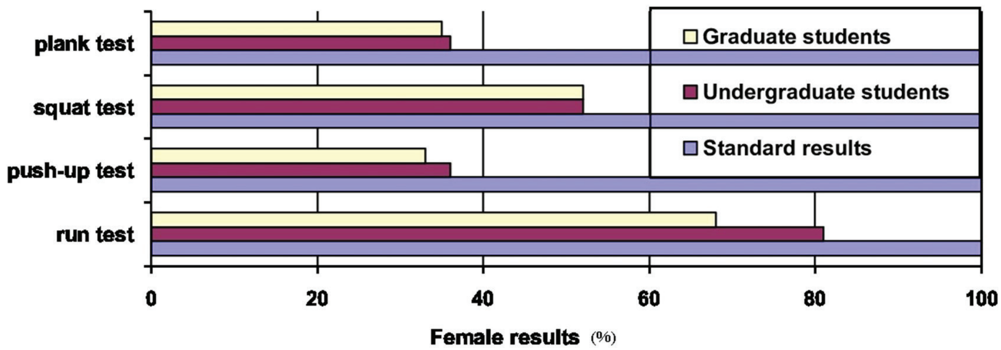


FIGURE 1. The ratio of the test results of female students with the standard results Functional fitness assessment tests

Discussion

The results obtained differ significantly from the results of PA female students' assessment in several European countries. The weekly PA volume of Bosnian female students was found to be at least 4600 minutes (Mulahasanović et al., 2018). Ukrainian female students have a PA of at least 3,100 minutes per week (Bergier et al., 2018). The maximum weekly volume of the PA of female graduate students is slightly more than 3000 minutes, as recorded in our studies. The volume of the PA of female undergraduate students is lower by approximately 100–150 minutes per week. The data from other Russian experts confirm the lower volume of weekly PA Russian female students. Scientists point out that the total amount of PA in female students is approximately 2900–3200 minutes per week (Nikolaev & Solodilov, 2016). A significant increase in the volume of PA in Russian female students is necessary because the volume of PA is related to significant public health and psychological benefits (Acebes-Sánchez, Diez-Vega, Esteban-Gonzalo, & Rodriguez-Romo, 2019).

The results of the research show that the majority of female students (more 60%) assess their level of weekly PA positively. The obtained results differ from the estimates of physical activity by students of other European countries. In the Czech Republic and Poland, only about 33% of students who indicated a preference for fitness PA (Kudlacek, Fromel, & Groffik, 2020). The global PA recommendations for adolescents and students are 60 min of moderate-to-vigorous intensity aerobic activity per day, plus three additional bouts of resistance exercise. The scientific literature presents data on the performance of female students' recommended weekly volume of PA only taking into account the mandatory attendance of PE classes (Marttinen et al., 2018). Compulsory physical education classes are not represented in the educational programs of female graduate students. The lack of regular PA adversely affects the level of physical fitness profile of female students (Osipov, Ratmanskaya, T., Nagovitsyn, R., Zhuikova, S., & Iermakov, 2020). We assume that many female students unreasonably indicate a higher level of PA in the IPAQ data. Activities to increase the motivation of female students for regular PE classes (Osipov et al., 2017) and to develop young people's interest in increasing the weekly volume of PA are needed (Bogdanov & Rychkova, 2019). Developing gender-specific programmes for promoting healthy lifestyle behaviours among students is recommended (Yahia et al., 2016). Foreign students studying at Russian universities emphasize the need for additional health fitness or sports (Tumakov, Fazleeva, Akberov, & Valeeva, 2018).

Experts indicated that university students have several modifiable risk factors associated with low levels of PA and excess weight (Concha-Cisternas et al., 2018; Grao-Cruces, Ruiz-Ariza, De la Torre-Cruz, & Martinez-Lopez, 2018). The female students with low levels of PA had significantly higher body mass and body composition parameters: body mass index and per cent body fat (Podstawski et al., 2019). However, the scientific literature provides data on a significant number of students who have a low weekly PA level and body weight within normal limits (Galle et al., 2019). Some studies show a significant prevalence of healthy BMI in students with lower PA levels in Ukraine and the Visegrad countries (Bergier et al., 2018). Our research also shows the prevalence of normal BMI in most female graduate and undergraduate students. We assume that most female students associate appearance and body weight with a sufficient level of PA. The females happy with their appearance consider the weekly PA level positive and do not see the need for an increase in PA.

Given the results of our study, we can affirm that the current conditions of student learning are characterized by a significant decrease in physical fitness indicators of female students. Experts say that the main reason is the low weekly PA level of female students. Significantly lower levels of weekly PA of Russian female students in comparison with those of female students of other European countries have been revealed. Most of the Russian female students have positive assessments of their weekly PA level. Similar assessments of the PA level are not completely objective. The prevalence of normal BMI in the majority of female students was also revealed. The female graduate students have significantly ($P<0.05$) higher rates of BMI in comparison with female undergraduate students. The female students with normal BMI have low results in functional fitness assessment tests. Increasing the total amount of weekly PA and improving the quality of PA of female students is recommended.

Acknowledgements
There are no acknowledgements.

Conflict of Interest
The authors declare that there are no conflicts of interest.

Received: 04 April 2020 | **Accepted:** 28 May 2020 | **Published:** 01 February 2021

References

Acebes-Sánchez, J., Diez-Vega, I., Esteban-Gonzalo, S., & Rodriguez-Romo, G. (2019). Physical activity and emotional intelligence among undergraduate students: a correlational study. *BMC Public Health, 19*(1), 1241. doi:10.1186/s12889-019-7576-5

Bergier, B., Bergier, J., Niźnikowska, E., Junger, J., Salonna, F., Ács, P., & Frömel, K. (2018). Differences in physical activity and nutritionand silhouette-related behaviours in male and female students in selected European countries. *Ann Agric Environ Med., 25*(1), 176-181. https://doi.org/10.26444/aaem/80988

Bergier, J., Tsos, A., Popovych, D., Bergier, B., Niźnikowska, E., Ács, P., Junger, J., & Salonna, F. (2018). Level of and factors determining physical activity in students in Ukraine and the Visegrad countries. *International Journal of Environmental Research and Public Health, 15*(8), 1738. doi:10.3390/ijerph15081738

Bergier, J., Bergier, B., & Tsos, A. (2017). Variations in physical activity of male and female students from the Ukraine in health-promoting life style. *Annals of Agricultural and Environmental Medicine, 24*(2), 217-221. doi:10.5604/12321966.1230674

Bogdanov, I., & Rychkova, N. (2019). Effect of emotional status and personality traits on physical preparedness in young people. *Human, Sport, Medicine, 19*(1), 80-85.

Bukova, A., Zuskova, K., Szerdiová, L., & Kuchelová, Z. (2017). Demographic factors and physical activity of female undergraduates. *Physical Activity Review, 5*, 202-211. doi:10.16926/par.2017.05.25

Concha-Cisternas, Y., Guzmán-Muñoz, E., Valdés-Badilla, P., Lira-Cea, C., Petermann, F., & Celis-Morales, C. (2018). Levels of physical activity and excess body weight in university students. *Revista Medica de Chile, 146*(8), 840-849. doi:10.4067/s0034-98872018000800840

Frehlich, L., Friedenreich, C., Nettel-Aguirre, A., & McCormack, G. (2018). Test-retest reliability of a modified International Physical Activity Questionnaire (IPAQ) to capture neighbourhood physical activity. *Journal of Human Sport and Exercise, 13*(1), 174-187. doi:10.14198/jhse.2018.131.17

Gabrys, T., Nowak, Z., Michalski, C., Szmatlan-Gabrys, U., & Stanula, A. (2018). Obesity in 18-25-year-olds in relation to their physical activity, and lifestyle. *Physical Activity Review, 6*, 64-72. doi:10.16926/par.2018.06.09

Galle, F., Sabella, E., Da Molin, G., Liguori, G., Montagna, M., Orsi, G., Valerio, G., & Napoli, C. (2019). A cross-sectional study investigating lifestyle and weight perception of undergraduate students in southern Italy. *BMC Public Health, 19*(1), 1316. doi:10.1186/s12889-019-7695-z

Grao-Cruces, A., Ruiz-Ariza, A., De la Torre-Cruz, M., & Martinez-Lopez, E. (2018). Students with excess weight obtain lower physical fitness test scores in physical education than normal weight pairs: myth or reality? *Journal of Physical Education and Sport, 18*(3), 1562-1571. doi:10.7752/jpes.2018.03231

Juškelienė, V., & Česnavičienė, J. (2017). Physical activity and its determinants among first-year students of Lithuanian university of educational sciences. *Pedagogika, 128*(4), 217-231. doi:10.15823/p.2017.65.

Kolokoltsev, M., & Iermakov, S. (2019). Morphofunctional and motor characteristics of Baikal region's students (Russia) with overweight. *Pedagogics, psychology, medical-biological problems of physical training and sports, 23*(1), 4-13. doi:10.15561/18189172.2019.0101

Kudlacek, M., Fromel, K., & Groffik, D. (2020). Associations between adolescents' preference for fitness activities and achieving the recommended weekly level of physical activity. *Journal of Exercise Science & Fitness, 18*(1), 31-39. doi:10.1016/j.jesf.2019.10.001

Kudryavtsev, M., Kramida, I., & Osipov, A. (2016). Influence of monitor bad habits on healthy lifestyle of students. *Teoriya i Praktika Fizicheskoy Kultury, 6*, 24-26.

Leuciuc, F. (2018). Perception on physical education among students. *Revista Romaneasca pentru Educatie Multidimensionala, 10*(2), 134-143.

Loginov, S., Nikolaev, A., Vetoshnikov, A., & Sagadeeva, S. (2015). Evaluation of physical activity of Surgut residents according to international questionnaire IPAQ. *Teoriya i Praktika Fizicheskoy Kultury, 1*, 83-85.

Marttinen, R., Fredrick, R., & Silverman, S. (2018). Middle school students' free-living physical activity on physical education days, non-physical education days, and weekends. *Montenegrin Journal of Sports Science and Medicine, 7*(1), 5-12. doi:10.26773/mjssm.180301

Mulahasanović, I., Mujanović, A., Mujanovic, E., Atikovic, A., & Maglaj, E. (2018). Level of physical activity of the students at the university of Tuzla according to IPAQ. *Central European Journal of Sport Sciences and Medicine, 21*(1), 23-30. doi:10.18276/cej.2018.1-03

Nikolaev, A., & Solodilov, R. (2016). Reliability of the international physical activity questionnaire (IPAQ-RU) as applied to sample student respondents. *Vestnik Surgutskogo gosudarstvennogo universiteta, 3*(13), 116-119. [In Russian]

Osipov, A., Ratmanskaya, T., Nagovitsyn, R., Zhuikova, S., & Iermakov, S. (2020). Increasing the level of cardiorespiratory and strength endurance of female students by means of mixed training (Kangoo–jumps fitness and resistance training). *Physical Activity Review, 8*(2), 38-47. doi:10.16926/par.2020.08.19

Osipov, A., Iermakov, S., Gruzinky, V., Kudryavtsev, M., Bliznevsky, A., Bliznevskaya, V., et al. (2018). Analysis of the parameter changes of students' physical development (at the age of 18–20) to identify the threat of increased body weight and obesity. *Journal of Physical Education and Sport, 18*(2), 800-809. doi:10.7752/jpes.2018.02118

Osipov, A., Kudryavtsev, M., Fedorova, P., Serzhanova, Z., Panov, E., Zakharova, L., … Klimuk, Y. (2017). Components of positive impact of exposure on university physical culture and sports on students' physical activity. *Journal of Physical Education and Sport*, *17*(2), 871-878. doi:10.7752/jpes.2017.02133

Pedisic, Z., Rakovac, M., Bennie, J., Jurakic, D., & Bauman, A. (2014). Levels and correlates of domain-specific physical activity in university students: Cross-sectional findings from Croatia. *Kinesiology, 46*(1), 12-22.

Podstawski, R., Żurek, P., Clark, C., Choszcz, D., Kusińska, E., & Omelan, A. (2019). Motor performance according to physical activity levels. *South African Journal for Research in Sport, Physical Education and Recreation, 41*(1), 103-119.

Şar Nuriye, Ş., Soyer, F., & Koç, M. (2018). An analysis of psychological endurance and personality traits of individuals doing sports and not doing sports by various variables. *Physical education of students, 22*(2), 91-98. doi:10.15561/20755279.2018.0206

Tinazci, C., EAlrefai, S., & Musa, O. (2019). Patterns of physical activity of Libyan undergraduate students at the university of Tripoli using international physical activity questionnaire (IPAQ). *Sport Mont, 17*(2), 103-106. doi:10.26773/smj.190618

Tumakov, D., Fazleeva, E., Akberov, R., & Valeeva, A. (2018). Adaptation to physical activities by international students at a Russian University. *South African Journal for Research in Sport, Physical Education and Recreation, 40*(1), 157-166.

Yahia, N., Wang, D., Rapley, M., & Dey, R. (2016).Assessment of weight status, dietary habits and beliefs, physical activity, and nutritional knowledge among university students. *Perspectives in Public Health, 136*(4), 231-244. doi:10.1177/1757913915609945

Zyurin, E., Bobkova, E., Morozov, V., & Poliyevsky, S. (2018). Mass physical fitness tests in context of Russian Physical Culture and Sports GTO complex reinstatement project implementation in 2016-17. *Teoriya i Praktika Fizicheskoy Kultury, 11*, 41-43.

DOI 10.26773/smj.210219

ORIGINAL SCIENTIFIC PAPER

Influence of Sambo Wrestling Training on Students' Physical Fitness

Grygoriy Griban[1], Dmytro Dzenzeliuk[2], Zoia Dikhtiarenko[3], Eduard Yeromenko[3], Andrii Lytvynenko[4], Olena Otravenko[5], Bogdan Semeniv[6], Volodymyr Prystynskyi[7] and Kostiantyn Prontenko[8]

[1]Zhytomyr Ivan Franko State University, Department of Physical Education and Sport Improvement, Zhytomyr, Ukraine, [2]University of Ukraine, Zhytomyr Economic and Humanitarian Institute of the Higher Educational Institution, Department of Social Rehabilitation Technologies, Zhytomyr, Ukraine, [3]National University of the State Fiscal Service of Ukraine, Department of Horting and Rehabilitation, Irpin, Ukraine, [4]Kharkiv National University of Radio Electronics, Department of Physical Education, Kharkiv, Ukraine, [5]Luhansk Taras Shevchenko National University, Department of Theory and Methods of Physical Education, Starobilsk, Ukraine, [6]Stepan Gzhytskyi National University of Veterinary Medicine and Biotechnologies Lviv, Department of Physical Education, Sports and Health, Lviv, Ukraine, [7]Donbas State Pedagogical University, Department of Theoretical and Methodological Foundations of Physical Education and Rehabilitation, Slavyansk, Ukraine, [8]S. P. Koroliov Zhytomyr Military Institute, Department of Physical Education, Special Physical Training and Sport, Zhytomyr, Ukraine

Abstract

Concerning the low level of physical fitness of Ukrainian students and insufficient motivation to do physical exercises, one potential solution is the implementation of specific sport-oriented physical education classes, taking into account students' choice of sport. The influence of sambo (self-defence without arms) wrestling training on the level and dynamics of students' physical fitness when studying at higher educational institutions is examined in the article. The investigation of students' physical fitness was conducted according to the following tests: 100-metre race, pull-ups (male), push-ups (female), 3000-metre race (male), 2000-metre race (female), shuttle run 4 × 9 m, sit-ups (per 1 min), standing long jumps, forward inclinations of the body in sitting position. The significantly better ($p<0.05$–0.001) physical fitness level of students who were involved in the sambo wrestling training during studying in comparison with students who were involved in the current system of physical education was determined, which proves the efficiency of sambo wrestling training. The improvement of students' physical fitness during sambo wrestling classes will have a positive influence on their physical working capacity and the efficiency of their studying and future professional activities.

Keywords: *physical fitness, students, sambo wrestling*

Introduction

Increasing study load and the intensification of the pedagogical process at Ukrainian higher educational institutions (HEI) are connected with ensuring the psycho-physical readiness of future specialists for professional activity. Physical education is an essential component of higher education aimed at the formation of a harmoniously developed modern specialist in the conditions of rationally organized motor activity (Radziyevsky, 2017; L. Shuba & V. Shuba, 2017). It has been proven that systematic physical training promotes health, the improvement of physical and mental capacities, and increases the quality of studying (Wernbom, Augustsson, & Thomee, 2007; Costa et al., 2016). However, according to the data of many scientists (Bolotin & Bakayev, 2015; Semeniv, Babych, Bilenkyi, Prystavskyi, & Kovban, 2018), the level of physical fitness and health of the students of HEI has decreased significantly during the recent years; it has been reported that most of the students have had certain health problems. Also, to increase the motivation of students to perform physical exercises systematically to ensure their health and professional longevity is an acute problem (Batilani, Belem, & Both, 2018; Leuciuc, 2018;

Correspondence:

K. Prontenko
S. P. Koroliov Zhytomyr Military Institute, Department of Physical Education, Special Physical Training and Sport, Mira str., 22, 10001, Zhytomyr, Ukraine
E-mail: prontenko-kostya@ukr.net

Mehmeti & Halila, 2018). A low motivation level of students is reflected in theirattendance in physical education classes. The scientists (Mandic, Wilson, Clark-Gril, & O'Neill, 2018; Mozolev et al., 2019; Prontenko et al., 2019) consider that the low level of the students' physical fitness is caused by the following: a low level of physical fitness of school graduates; studying conditions in modern HEI characterized by increased study load and a low physical activity level; the lack of the students' interest in traditional classes in physical education; the lack of possibility to choose the type of physical activity. Concerning the data of many scientists (Altin &Demir, 2019; Bergier et al., 2017; Prontenko et al., 2020), one potential means of improving the physical fitness of Ukrainian students is the implementation of sport-oriented physical education classes into the educational process, taking into account the students' free choice of sport. Additionally, the popularity of the type of sport among the students, the training base of an HEI, and the specialists among the teaching staff of the departments of physical education should be taken into account. The analysis of the literature (Troyanov, 2002; Osipov et al., 2017; Slimani, Davis, Franchini, & Moalla, 2017) showed that the most popular sports among students are modern martial arts and various kinds of wrestling.

The present study aims to investigate the influence of sambo wrestling training on the level and dynamics of students' physical fitness at Ukrainian higher educational institutions.

Methods

Ninety-four students (51 male and 43 female) of Zhytomyr Ivan Franko State University took part in the research. Two experimental and two control groups were formed: experimental group - EG1 (N=25) and control group - CG1 (N=26) involved male students (N=51); experimental group - EG2 (N=21) and control group - CG2 (N=22) involved female students (N=43). The experimental and control groups included the students of the first year of study, aged 17–20, who had significantly identical indicators of physical fitness at the beginning of the study ($p>0.05$). The students of EG1 and EG2 were engaged in sambo wrestling classes according to the programme of the authors of the present paper (during physical education classes (sports department)); the students of CG1 and CG2 were engaged in classes according to the current programme of physical education (main department). The total number of hours spent on physical education per week by the students of both groups was the same and it equaled 4 hours.

The implementation of the authors' programme meant that students would master the following minimum required range of sambo techniques: self-insurance techniques (falling forward, backward, to the right side, to the left side); gymnastic exercises (forward and backward rolling, backward rolling with jumping, exercises cartwheel, round off, crab position); exercises for the development of neck muscles (running around the neck, jumping on the neck, rolling over the neck, etc.); common basic techniques for sambo wrestling (the ability to move correctly on the mat during a fight in pairs, different options for grips, etc.); the skills of simple methods of fighting in lying position and standing (disturbing the balance, back and front chips, throw through the thigh, grape-vine, leg takedown, throw taking popliteal arch, in standing and on the knees, foot lean on the abdomen, grip of feet, side sweep and pace of steps, painful techniques for arm and leg, side holding, holding from the head side, holding from the legs side, cross-holding, holding above); initial judicial practice.

To achieve the aim of the investigation, we conducted a pedagogical experiment from 2017 to 2019. The analysis of the indicators of students' physical fitness was conducted according to the following tests: 100 m race, pull-ups (male), push-ups (female), 3000 m race (male), 2000 m race (female), shuttle run 4 × 9 m, sit-ups in 1 min, standing long jumps, forward inclinations of body from a sitting position. The examination was conducted according to the Regulation on the State Tests and Standards of Evaluation of the Physical Fitness of the Population of Ukraine (2014). The levels of students' physical fitness were defined through the total points in seven tests. To receive an individual assessment as excellent and a high level of physical fitness, the total points should be 45–50; the higher than the middle level 35–44 points; a middle level 25–34 points; below the middle level 15–24 points; a low level 10–14 points. Monitoring of the level and dynamics of the indicators of students' physical fitness was carried out four times during the first and the second years of study (in 1st– 4th terms); i.e., there were four stages of the investigation. Research methods included theoretical analysis and generalization of literature, pedagogical observation, questionnaire survey, testing, pedagogical experiment, and methods of mathematical statistics. During the study, the authenticity of the difference between the indicators of students by means of Student's t-test was determined. The significance was set at $p<0.05$ for all statistical tests.

This study complies with the ethical standards of the Act of Ukraine "On Higher Education" No. 1556-VII dated 01.07.2014 and the Letter from the Ministry of Education and Science of Ukraine "On the Academic Plagiarism Prevention" No. 1/11-8681 dated 15.08.2018, and also the principles of the Helsinki Declaration of the World Medical Association. Informed consent has been obtained from all individuals included in this study.

Results

According to regulatory documents regarding the organization of the educational process in physical education at

Table 1. The types of sport in which students would like to be engaged in during physical education classes

Types of sport	Males (N=238)	Rating	Females (N=197)	Rating
Football	31.5%	1	3.7%	8
Volleyball	4.2%	7	32.9%	1
Basketball	9.2%	4	4.1%	7
Track and field athletics	5.1%	5	5.1%	4
Sambo wrestling	29.8%	2	31.5%	2
Kettlebell lifting	4.2%	6	4.6%	5
Powerlifting	13.5%	3	4.1%	6
Badminton	2.5%	8	14.2%	3

Ukrainian HEIs, the sections of the department of physical education and relevant studying groups are completed in the 1st year of study at the beginning of the academic year concerning the sports interests of students, their level of health, physical fitness, and sport qualification. The data necessary to complete the sections of the department were obtained by questioning the students. The sports section involved the students who wanted to improve their sports qualification in the kinds of sport suggested. The results of the students' questionnaire conducted at the beginning of the 1st year of study (2017) (238 male students and 197 female students) determined that 81.5% of male and 84.8% of female students prefer optional classes. Moreover, most of them wanted to be engaged in sport sections (football: 31.5% male, volleyball: 32.9% female students) and sambo wrestling (29.8% male and 31.5% female) (Table 1).

Sambo wrestling benefits from the vast amount of practical experience gained by all kinds of wrestling, which does not require excessive material for mastering skills and which is available for self-development and self-improvement (Tron et al., 2018; Polat, Cetin, Yarim, Bulgay, & Cicioglu, 2018; Dzenzeliuk, 2015). Due to a wide range of technical and tactical actions and high dynamism, sambo wrestling is popular among young people. In addition, sambo wrestling has an applied orientation of skill relevant for various professions, and it is used for military physical training in the army and police in almost all countries of the world. The range of technical and tactical actions recommended and used in the process of applied training includes protection against various types of attack, as well as throws, strokes, and pain and suffocating techniques. The use of special protective equipment when studying and improving the sambo wrestling technique helps to bring the learning process closer to real situations and does not reduce the quality of the performance. The analysis of the works of scientists who investigated the influence of different martial arts on the body (Dornowski, Jagiello, & Smaruj, 2011; Chernozub et al., 2019) proves their positive effect on functional state, physical fitness, working capacity, health and volitional qualities.

Concerning the results of personal investigations, we created and grounded the authors' programme of the students' physical qualities development by the means of sambo wrestling. The tasks of the program are: 1) the increase of the students' desire and interest in physical education classes; 2) the improvement of the systematic attendance of physical education classes; 3) the increase in the level of students' physical fitness and health; 4) the formation of motivation for regular physical exercises; 5) the formation of knowledge, skills and abilities of technical and tactical actions in sambo wrestling; 6) gaining experience of creative use of physical health-improving and sports activities for the achievement of personal and professional goals.

In the authors' programme, the classes are based on the methodical principles of physical education (consciousness and activity, visibility, simplicity and individualization, systematic and consistency, progression), and principles of sports training (continuity, insightful specialization, the unity of gradual increase in load and tendency to maximum loads, undulating and variable loads changes, cycle). The main methods of training are steady, variable, interval, repeated, and competitive. The load at the stages of the authors' programme was adjusted by the changes in its volume and intensity, magnitude and orientation taking into account the individual abilities of each student, the level of readiness, weight category, gender; it was determined by the specifics of application and the order of combination of the next components: the type, duration and character of individual exercises, the number of repetitions, fights, the intensity of work during their performance (the tempo of movements, the speed and time of their performance), the weight of load (partner), the technical complexity of methods, the duration and nature of the pauses between separate repetitions, and the number of exercises. The results of the study of the level and dynamics of physical fitness of students of both genders are given in Table 2.

The analysis of the results in the 100 m race showed that the difference in the indicators of EG1 and CG1, EG2, and CG2 was not determined at the beginning of the experiment ($p>0.05$). At the second and the third stages, the speed indicators of experimental groups were 0.1–0.3 sec better than those of control groups, but the difference was not significant ($p>0.05$). The considerably better results of the students of experimental groups are discovered at the fourth stage: the difference of the male students in 100 m race is 0.4 sec ($p<0.05$); for female students, it is 0.4 sec ($p<0.05$).

A comparative analysis of the results of students in pull-ups showed that only at the first stage; the strength indicators of male students did not differ significantly ($p>0.05$). At all other stages, the results of the EG1 students were significantly better than the CG1 students ($p<0.01$–0.001) (Table 2). During the experiment, the results of the EG1 students in pull-ups were 7.4 times increased ($p<0.001$); among the CG1 students, it was 0.9 times increased ($p>0.05$). The investigation of the female students' results in push-ups showed that at the first stage, the strength qualities of both groups did not differ significantly ($p>0.05$). At the second stage, the results of the EG2 started to be better significantly ($p<0.001$) than the result of the CG2: 5.1 times better at the second stage, 9.3 times better at the third stage, and 12.6 times better at the 4th stage, which proves a positive influence of the classes according to the authors' programme on the female students' strength qualities development. The analysis of the dynamics of female students' strength indicators during the experiment showed that the results of EG2 were increased significantly (by 13.2 times, $p<0.001$); CG2 was just 0.7 times increased ($p>0.05$).

The investigation of the level of students' endurance development proved that the male students' results in 3000 m race were equal at the 1st stage (14 min 41 sec and 14 min 43 sec, $p>0.05$) (Table 2). The endurance development indicators of the EG1 students were significantly better than those of the CG1 students at the second and further stages of the research. The analysis of the dynamics of the students' results during the experiment showed that the indicators of EG1 were significantly improved by 1 min 50 sec ($p<0.001$) and equal 12 min 51 sec at the fourth stage. The results of CG1 were not changed; the difference in the initial and final data is just 7.6 sec ($p>0.05$). The analysis of the dynamics of female students results in 2000 m race proved the similar tendency: the results of EG2 were improved significantly during the experiment ($p<0.001$), the endurance development indicators of CG2 remained unchanged. Additionally, no authentic difference in the indicators of EG2 and CG2 was determined just at the first stage ($p>0.05$), the results of the female students of EG2 were significantly better than the ones of CG2 at the other stages.

The analysis of the results in 4 ×9 m shuttle run showed

Table 2. The dynamics of the physical qualities development of the EG and CG students during the experiment (N=94)

The stages of the experiment	Male students			Female students		
	EG1 (N=25) M±SD	CG1 (N=26) M±SD	p (EG1-CG1)	EG2 (N=21) M±SD	CG2 (N=22) M±SD	p (EG2-CG2)
100 m race, sec						
1st term	14.4±0.16	14.3±0.14	>0.05	16.9±0.14	17.0±0.15	>0.05
2nd term	14.1±0.15	14.2±0.13	>0.05	16.6±0.12	16.8±0.14	>0.05
3rd term	13.9±0.15	14.2±0.12	>0.05	16.5±0.12	16.8±0.15	>0.05
4th term	13.8±0.14	14.2±0.12	<0.05	16.3±0.11	16.7±0.13	<0.05
p (1–4)	<0.01	>0.05		<0.01	>0.05	
Pull-ups (male), push-ups (female), reps						
1st term	9.4±0.52	9.6±0.49	>0.05	13.2±0.60	13.1±0.58	>0.05
2nd term	12.5±0.49	10.3±0.51	<0.01	18.7±0.57	13.6±0.57	<0.001
3rd term	14.9±0.46	10.2±0.48	<0.001	23.1±0.55	13.8±0.56	<0.001
4th term	16.8±0.46	10.5±0.47	<0.001	26.4±0.54	13.8±0.55	<0.001
p (1–4)	<0.001	>0.05		<0.001	>0.05	
3000 m race (male), 2000 m race (female), sec						
1st term	881.2±12.71	882.9±12.88	>0.05	802.3±10.91	797.7±10.43	>0.05
2nd term	835.8±12.55	880.4±12.81	<0.05	728.4±10.62	800.2±10.32	<0.001
3rd term	796.4±12.47	877.0±12.75	<0.001	690.7±10.53	804.9±10.25	<0.001
4th term	771.1±12.36	875.3±12.69	<0.001	667.2±10.39	799.1±10.27	<0.001
p (1–4)	<0.001	>0.05		<0.001	>0.05	
Shuttle run 4 x 9 m, sec						
1st term	9.9±0.49	9.8±0.47	>0.05	11.2±0.65	11.3±0.68	>0.05
2nd term	9.6±0.43	9.6±0.45	>0.05	10.9±0.62	11.0±0.65	>0.05
3rd term	9.3±0.42	9.5±0.43	>0.05	10.6±0.61	10.8±0.69	>0.05
4th term	9.1±0.39	9.4±0.42	>0.05	10.4±0.59	10.7±0.62	>0.05
p (1–4)	>0.05	>0.05		>0.05	>0.05	
Sit-ups in 1 min, reps						
1st term	39.2±1.14	39.1±1.17	>0.05	29.3±1.23	30.1±1.19	>0.05
2nd term	42.8±1.13	40.3±1.13	>0.05	36.6±1.25	32.6±1.17	<0.05
3rd term	45.6±1.15	41.6±1.12	<0.05	38.4±1.22	33.2±1.17	<0.01
4th term	48.9±1.16	42.2±1.10	<0.001	42.1±1.18	33.5±1.16	<0.001
p (1–4)	<0.001	>0.05		<0.001	>0.05	
Standing long jump, cm						
1st term	219.3±2.93	220.4±2.89	>0.05	170.2±2.48	171.3±2.55	>0.05
2nd term	228.4±2.95	225.8±2.85	>0.05	177.9±2.52	173.7±2.54	>0.05
3rd term	236.9±3.02	226.1±2.83	<0.05	184.3±2.47	175.9±2.51	<0.05
4th term	243.2±2.96	227.6±2.81	<0.001	188.5±2.43	176.3±2.49	<0.001
p (1–4)	<0.001	>0.05		<0.001	>0.05	
Forward inclination of body from a sitting position, cm						
1st term	8.1±1.07	8.0±1.12	>0.05	12.7±1.05	12.6±1.06	>0.05
2nd term	14.7±1.04	7.8±1.11	<0.001	16.5±1.03	13.5±1.02	<0.05
3rd term	16.2±1.02	7.8±1.10	<0.001	19.8±1.05	14.1±1.06	<0.01
4th term	18.6±0.98	7.7±1.10	<0.001	21.2±1.04	14.5±1.05	<0.001
p (1–4)	<0.001	>0.05		<0.001	>0.05	

Legend: Mean: arithmetical average; SD: standard deviation; N: number of subjects; EG1 – Experimental group 1; CG1 Control group 1; p (EG1–CG1): significance of difference between the indicators of EG1 and CG1 due to the t-test; p (1–4): significance of difference between the indicators of each group at the beginning and at the end of the experiment due to the t-test that the indicators of dexterity development of the students of both groups did not differ authentically at the first, second, third, and fourth stages of the investigation (p>0.05) (Table 2). The dynamics of the results of students (male and female) in 4 × 9 m shuttle run have a positive character during the experiment: the indicators were improved in all groups: EG1: 0.8 sec, CG1: 0.4 sec, EG2: 0.8 sec, and CG2: 0.6 sec (p>0.05).

The analysis of the male students' results in sit-ups in 1 min showed that the results of EG1 and CG1 did not differ significantly at the first and the second stages of the experiment (p>0.05) (Table 2). The results of EG1 were four times better significantly than the indicators of CG1 at the third stage (p<0.05), and 6.7 times better at the fourth stage (p<0.001). The indicators of EG1 were 9.7 times increased (p<0.001), and those of CG1 were not changed (p>0.05) during the experiment. The difference in the results in sit-ups of the female students of EG2 and CG2 was not defined at the 1st stage of the experiment (p>0.05), and the difference was authentic at the further stages. The results of EG2 in this exercise were increased 12.8 times (p<0.001), while in CG2 it was increased 3.4 times (p>0.05) during the experiment.

The examination of the students' results in standing long jump proved that the results of both male and female students did not differ significantly at the first and the second stages of the experiment (p>0.05) (Table 2). The result of EG1 was 10.8 cm better significantly than the one of CG1 (p<0.05) at the third stage, and 15.6 cm at the fourth stage (p<0.001). The results of EG2 were 8.4 cm better than the results of CG2 (p<0.05) at the third stage, and 12.2 cm at the fourth stage (p<0.001).

The implementation of the authors' program promoted more efficient development of flexibility of both male and female students of EG, in comparison to CG. Therefore, the results in forward inclination of body from a sitting position were better significantly in experimental groups than in control groups even at the second stage (p<0.05–0.001) (Table 2). During the experiment, the indicators of the students of experimental groups were 10.5 cm increased in EG1 and 8.5 cm in EG2 (p<0.001).

An individual grade, as well as the level of physical fitness of students in accordance with the regulations on the state tests and standards, was determined by the total points of the results in seven control exercises. The study of the level of physical fitness of the students of experimental and control groups by the total points showed that at the beginning of the experiment, total points were the same in EG1 and CG1, which equalled 13 points and corresponded to the low level of physical fitness (Table 3).

Table 3. The dynamics of the physical fitness level of EG1 (N=25) and CG1 (N=26) male students during the experiment (in points)

Tests	1st term		2nd term		3rd term		4th term	
	EG1	CG1	EG1	CG1	EG1	CG1	EG1	CG1
100 m race	3	3	4	3	4	3	4	3
Pull-ups	1	1	3	2	4	2	5	2
3000 m race	2	2	3	2	3	2	4	2
Shuttle run 4 x 9 m	2	3	3	3	3	3	4	3
Sit-ups in 1 min	2	2	3	2	3	3	4	3
Standing long jump	1	1	1	1	4	2	4	3
Forward inclination of body	2	1	2	1	4	1	4	1
Sum of points	13	13	19	14	25	16	29	17

During the experiment, the level of physical fitness increased in both groups: the total points were 29 points in EG1 at the fourth stage, which corresponds to the middle level of physical fitness, and 17 points in CG1, which corresponds to the below the middle level. The greatest increase of grade of the students of EG1 was found in the development of strength, endurance, speed and strength qualities, and the flexibility test.

The sum of points of EG2 and CG2 was the same at the beginning of the experiment (11 points in every group), which corresponded to a low level. During the experiment, the sum of points was increased: 27 points in EG2 (the middle level), 15 points in CG2 (below the middle level) (Table 4).

Table 4. The dynamics of the physical fitness level of the EG2 (N=21) and CG2 (N=22) female students during the experiment (in points)

Tests	1st term		2nd term		3rd term		4th term	
	EG2	CG2	EG2	CG2	EG2	CG2	EG2	CG2
100 m race	2	2	2	2	2	2	3	2
Push-ups	2	2	3	2	4	2	5	2
2000 m race	1	1	2	1	2	1	3	1
Shuttle run 4 x 9 m	2	2	3	3	3	3	4	3
Sit-ups in 1 min	1	1	2	2	3	2	4	2
Standing long jump	1	1	2	1	3	2	3	2
Forward inclination of body	2	2	3	2	4	2	5	3
Sum of points	11	11	17	13	21	14	27	15

Taking into account the dynamics of students' level of physical fitness during their first and second years of studies, we may predict a further increase in the level of physical fitness in the senior years of study on the condition of sambo wrestling classes in the sports section of the department of physical education at the HEI.

Discussion

The works of scientists (Azhyppo et al., 2018; Prontenko et al., 2019) determine that the level of physical fitness of students of Ukrainian HEIs is not satisfactory and has a downward trend; the number of students who have health problems increases every year. This leads to the students' excess weight, decreased health and efficiency of studying, and significant limitations on the ability of young people to choose a profession and job.

Researchers (Montesano & Mazzeo, 2019; Mozolev et al., 2019) consider one of the possible ways to solve this problem to be a students' free choice of the type of physical health-improvement and sports activity, taking into account the popularity of the sport among students, the possibility of the educational and sports base of the HEI and the specialists among the teaching staff of the department of physical education. Researchers (Prysiazhniuk et al., 2018) mention that the number of students who would like to participate in sports sections during their studying at the HEI ranges from 50 to 80%, which proves the necessity to adjust the physical educational process to the interests, motivations, and needs of students. Consequently, we developed and substantiated the authors' program of the development of the physical qualities of the students by means of sambo wrestling. The results of the experiment showed that the physical education classes according to the authors' programme had a positive effect on the level of physical fitness of both male and female students. Thus, under the influence of organized sambo wrestling classes, an authentic improvement in the level of speed, strength, endurance, speed and strength, a flexibility of both male and female students is observed. In general, improved physical fitness will have a positive effect on the students' mental and physical capacity, their health, well-being, and the effectiveness of their senior studying and future professional activity.

Acknowledgements
There are no acknowledgements.

Conflict of Interest
The authors declare that there are no conflicts of interest.

Received: 06 April 2020 | **Accepted:** 01 June 2020 | **Published:** 01 February 2021

References

Altin, M, & Demir, H. A. (2019). Study of humor differences in university students doing and not doing sport. *International Journal of Applied Exercise Physiology, 8*(1), 149-158. doi: 10.30472/ijaep.v8i1.318

Azhyppo, O., Pavlenko, V., Mulyk, V., Mulyk, K., Karpets, L., Grynova, T., … Sannikova, M. (2018). Direction of teaching the subject of physical education by taking into account opportunities of institution of higher education and interests of student youth. *Journal of Physical Education and Sport, 18*(1), 222-229. doi: 10.7752/jpes.2018.01029

Batilani, T. G., Belem, I. C., & Both, J. (2018). Different profiles in terms of motivation and concerns of physical education students. *Movimento, 24*(2), 619-632. doi: 10.22456/1982-8918.74947

Bergier, J., Niznikowska, E., Bergier, B., Acs, P., Salonna, F., & Junger, J. (2017). Differences in physical activity, nutritional behaviors, and body silhouette concern among boys and girls from selected European countries. *Human Movement, 18*(1), 19-28. doi: 10.1515/humo-2017-0009

Bolotin, A., & Bakayev, V. (2015). Structure and content of the educational technology of managing students' healthy lifestyle. *Journal of Physical Education and Sport, 15*(3), 362-364. doi: 10.7752/jpes.2015.03054

Chernozub, A., Danylchenko, S., Imas, Ye., Kochina, M., Ieremenko, N., Korobeynikov, G., ... Gorashchenco, A. (2019). Peculiarities of correcting load parameters in power training of mixed martial arts athletes. *Journal of Physical Education and Sport, 19*(2), 481-488. doi: 10.7752/jpes.2019.s2070

Costa, A. M., Gil, M. H., Sousa, A. C., Ensinas, V., Espada, M. C., & Pereira, A. (2016). Effects of concurrent strength and endurance training sequence order on physical fitness performance in adolescent students. *Journal of Physical Education and Sport, 16*(4), 1202-1206. doi: 10.7752/jpes.2016.04191

Dornowski, M., Jagiello, W., & Smaruj, M. (2011). Muscle strength and technical skills in 17–19-year-old judoists. *Baltic Journal of Health and Physical Activity, 3*(4), 262-268. doi: 10.2478/v10131-011-0025-1

Dzenzeliuk, D. O. (2015). Navchalna proghrama z borotby sambo dlya studentiv vyshhyh navchalnyh zakladiv [*Sambo wrestling training program for students of higher educational institutions*]. Zhytomyr: ZNAEU. [in Ukrainian].

Leuciuc, F. (2018). Perception on physical education among students. *Revista Româneascăpentru Educaţie Multidimensională, 10*(2), 134-143. doi: https://doi.org/10.18662/rrem/51

Montesano, P., & Mazzeo, F. (2019). Sports activities in obese teenagers improve social inclusion and health. *Sport Mont, 17*(1), 55-60. doi: 10.26773/smj.190210

Mandic, S., Wilson, H., Clark-Gril, M., & O'Neill, D. (2018). Physical activity learning module improves medical students' skills and confidence for advising patients about physical activity. *Montenegrin Journal of Sports Science and Medicine, 7*(1), 31-38. doi: 10.26773/mjssm.180304

Mehmeti, I., & Halila, B. (2018). How to increase motivation for physical activity among youth. *Sport Mont, 16*(1), 29-32. doi: 10.26773/smj.180206

Mozolev, O., Bloshchynskyi, I., Alieksieiev, O., Romanyshyna, L., Zdanevych, L., Melnychuk, I., ... Prontenko, V. (2019). Influence of modern fitness technologies on the state of health and development of motor abilities of 17–19-year-old female students. *Journal of Physical Education and Sport, 19*(Suppl. issue 3), 917-924. doi: 10.7752/jpes.2019.s3132

Osipov, A., Kudryavtsev, M., Gatilov, K., Zhavner, T., Klimuk, Yu., & Ponomareva, E. (2017). The use of functional training – crossfit methods to improve the level of special training of athletes who specialize in combat sambo. *Journal of Physical Education and Sport, 7*(3), 2013-2018. doi: 10.7752/jpes.2017.03201

Polat, S. C., Cetin, E., Yarim, I., Bulgay, C., &Cicioglu, H. I. (2018). Effect of ballistic warm-up on isokinetic strength, balance, agility, flexibility and speed in elite freestyle wrestlers. *Sport Mont, 16*(3), 85-89. doi:10.26773/smj.181015

Prontenko, K., Griban, G., Bloshchynskyi, I., Melnychuk, I., Popovych, D., Nazaruk, V., ... Novitska, I. (2020). Improvement of students' morpho-functional development and health in the process of sport-oriented physical education. *Wiadomości Lekarskie, 73*(1), 161-168. doi: 10.36740/WLek202001131

Prontenko, K., Griban, G., Dovgan, N., Loiko, O., Andreychuk, V., Tkachenko, P., ... Bloshchynskyi, I. (2019). Students' health and its interrelation with physical fitness level. *Sport Mont*. *17*(3), 41-46. doi 10.26773/smj.191018

Prysiazhniuk, S., Tolubko, V., Oleniev, D., Parczevskyy, Yu.,Prontenko, K., Griban, G., ... Zhyrnov, O. (2018). The influence of physical activities on biological age parameters of the first-year female students from the special medical department. *Journal of Physical Education and Sport, 18*(2), 561-564. doi: 10.7752/jpes.2018.02081

Radziyevsky, V. P. (2017). Theoretical analysis of the problem of physical education of students of medical universities, taking into account the peculiarities of their future professional activity. *Journal of Education, Health and Sport, 8,* 1021-1027. doi: http://dx.doi.org/10.5281/zenodo.1039733. eISSN 2391-8306

Semeniv, B., Babych, A., Bilenkyi, P., Prystavskyi, T., & Kovban, O. (2018). Educational model of physical training of students of bio-technological profiles. *Physical Education, Sports and Health Culture in Modern Society, 1*(41), 52-60. doi: https://doi.org/10.29038/2220-7481-2018-01-52-60

Shuba, L., & Shuba, V. (2017). Modernization of physical education of student youth. *Physical Education of Students, 21*(6), 310-316. doi: https://doi.org/10.15561/20755279.2017.0608

Slimani, M., Davis, P., Franchini, E., & Moalla, W. (2017). Rating of perceived exertion for quantification of training and combat loads during combat sport-specific activities: a short review. *Journal of Strength and Conditioning Research, 31*(10), 2889-2902. doi:10.1519/

JSC.0000000000002047
Tron, R., Hruzevych, I., Salnykova, S., Kormiltsev, S., Sarafynyuk, P., Kyrychenko, Yu., ... Kropta, R. (2018). Psychophysiological conditions and competition in highly qualified combat sambo wrestlers. *Journal of Physical Education and Sport, 18*(2), 600-605. doi: 10.7752/jpes.2018.02087
Troyanov, K. V. (2002). Metodyka nachalnoy podghotovky po borbe sambo v processe fyzycheskogho vospytanya studentov [*Methods of initial training in sambo wrestling in the process of physical education of students*]. Candidate's thesis. Moskva. [in Russian].
Wernbom, M., Augustsson, J., & Thomee, R. (2007). The influence of frequency, intensity, volume and mode of strength training on whole muscle cross-sectional area in humans. *Sports Medicine, 37*(3), 225-264. doi:http://doi.org/10.2165/00007256-200737030-00004

DOI 10.26773/smj.210206

ORIGINAL SCIENTIFIC PAPER

21st Century Coach Leadership Style towards Football Players' Motivation in Malaysian Sports Schools

Mohamad Nasrullah Nasiruddin[1,2], Mohd Norakmar Omar[1,2] and Mohd Sofian Omar-Fauzee[1]

[1]Northern University of Malaysia, School of Education and Modern Languages, Kedah, Malaysia, [2]Ministry of Education Malaysia, Scholarship and Finance Division, Selangor, Malaysia

Abstract

Malaysia has taken a rigorous approach to improving the quality and performance of its football teams. To match the strength of world-class football teams, the nation has taken a strategic approach by developing players' potential through the grassroots level. These players are brought together in sports schools across the country and trained by experienced coaches to showcase their talents, potentials, skills, and performance. Therefore, this study identifies the relationship between coach leadership style and the motivation of football players in sports schools. Furthermore, the study explores the dimensions of coach leadership style that have a high impact on improving player motivation. In this regard, a total of 313 footballers participating in the under-14 football tournament organized by the ministry of education and the national football development programme (NFDP) from sports schools across Malaysia surveyed as respondents. The findings show that there is a moderate positive relationship between coach leadership style and football players' motivation. Dimensions such as democratic and social consideration have a significant impact on increasing football players' motivation in sports schools. In conclusion, the football coach is the most crucial person in ensuring the motivation of football players at a high level. They have to use all of their existing skills to build a strong, motivated team and never tire of it when facing tough moments in the game.

Keywords: *football, sports school, players' motivation, coach leadership style, youth*

Introduction

Football is one of the most popular sports throughout the world, regardless of gender, age or educational background. It is a sport that has a great aura in creating unity among all races and communities. Internationally, football teams from South American and European countries, such as Brazil, Argentina, Uruguay, France, England, Spain, and Italy, are favourites among football fans, and their players are revered and idolized. Not to be overlooked is the Belgian football team that is now showing consistency and winning the top rating of the Federation Internationale de Football Association (FIFA) in recent years (FIFA, 2020).

In many countries, the quality of the football team is improving over time. National football teams, such as those of Japan, South Korea, China, Saudi Arabia, and Iran, are the major forces in Asia to qualify for the World Cup every four years (Cho, 2015). The quality of their games is far superior to that of other Asian teams. This situation has been a concern for most other Asian football teams as the chances of qualifying for the World Cup are increasingly difficult (Amara, 2017). It is even more alarming when Australia's presence in the Asia Football Confederation (AFC) further complicates the dream of a lower-ranked football team to set foot on the world's leading football field.

As a developing country in Asian football, Malaysia is aware

Correspondence:

M. N. Nasiruddin
Northern University of Malaysia, School of Education and Modern Languages, UUM Sintok, 06010 Kedah, Malaysia
E-mail: nasrullah871231@gmail.com

that higher level competition gives them a great opportunity to enhance their players' performance and overall team quality further. Therefore, the Football Association of Malaysia (FAM) is hoping for better-organized competition to enable them to compete against the top teams in Asia. Another opportunity is hosting the Asian Games in 2030, which means that Malaysian football teams automatically compete in the tournament (Rosly, 2019).

Of course, the most important thing to remember is that the process of football development starts at an early age. The method of finding talent from among young children is the most effective way of uncovering and shaping personalities, especially in physical, psychological, decision-making. and tactical development (Carroll, 2019). Children with potential should be brought together and given the full attention of the government by providing a wide range of facilities, initiatives, welfare and infrastructure training centres (Webb, Dicks, Brown, & O'Gorman., 2019). One measure taken by the Malaysian government is to place potential football students in sports schools around the country.

Football in Malaysia has experienced a slight decline in performance in recent times. According to FIFA (2020), Malaysia is ranked 167th out of 211 countries in the FIFA men's soccer rankings. The data in April 2020 is very different from the success Malaysia had on the international stage two decades ago. For example, Malaysia had previously ranked 75th in the FIFA rankings in August 1995 (Noor, 2014).

Several studies have found that the decline of Malaysian football is due to a lack of motivation among players (Govindan, Geok, Yusof, & Omar-Fauzee, 2019). Most players suffer from performance loss due to lack of motivation during matches. This situation is particularly worrying as it continues from the senior squad to the junior team. The national youth squad is among the school-aged between 13 and 17 years old. If factors such as motivation are not emphasized earlier, these young players will likely follow in the footsteps of senior players as they advance into the professional world (Dyakova, Dyakov, & Angelova, 2017).

Presently, a group of junior college football players has been gathered and are on-site at sports schools to pursue a more systematic intensive programme. These players train with a wide range of skills by experienced coaches, most of whom are former professional footballers and qualified teachers in the field of sports science (Govindan et al., 2019; Noor, 2014). The question arises: can these coaches improve the motivation of the football players at the school? The learning environment at a sports school is not the same as a regular school; apart from studying, students also need to focus on football (Din, Rashid, & Awang, 2015).

Several previous studies have shown that coach leadership style can enhance the well-being, motivation, and satisfaction of football among students (Lescroart, Brown, & Paskus, 2015; Mouloud & Elkader, 2016). However, the approach adopted by the study is very different as it involves respondents of different ages, study locations and methods of coaching techniques practised (Lee & Rengasamy, 2015). Given that Malaysia has a very unsettling history of football failure, it is appropriate that a study be conducted to examine the motivation level of junior players in the 2020s. Also, it is essential to examine the influence played by existing coaches to motivate players for the sake of football in Malaysia.

Based on recent issues, the study aims to identify the level of coach leadership style and football players' motivation at Malaysian Sports Schools. It also examined the relationship between coach leadership style and motivation among football players. Finally, the study details the effects of coach leadership style that can influence football players' motivation.

Methods

The population of this study is athletes involved in football games at State Sports Schools (SSS) and Malaysian Sports Schools (MSS). A total of 22 SSS and MSS schools exist throughout Malaysia, for athletes in the age range of 13 to 17 years. All athletes in various sports fields are trained intensively in sports, including academic accreditation by the Ministry of Education Malaysia (MOE) and the Ministry of Sport and Youth (MSY). According to the current situation, there are 6252 athletes in SSS and MSS. Of these, 550 are footballers between the ages of 13 and 14 who are participating in MOE-sponsored under-14 tournaments.

Based on the table of Krejcie and Morgan (1970), the minimum number of respondents to take in was 234 football players. To avoid problems such as missing questionnaires, inaccurate findings and incomplete forms, the number of respondents should be increased. Therefore, a total of 313 football players were selected as respondents in the study using a simple random sampling method.

The instrument used to measure coach leadership style is the Revised Leadership Scale for Sport (RLSS), which contains 60 items in total, covering six different dimensions (Zhang, Jensen, & Mann, 1997). The dimensions are about the leadership styles practised by the coach from the perspective of a young footballer. The RLSS has been widely used in studies involving coach leadership styles in various sports and has shown consistent values (Nazarudin, Omar-Fauzee, Jamalis, Geok, & Din, 2009; Sullivan & Dhurup, 2012).

Furthermore, another variable was the football players' motivation, which was adapted from the work of Pelletier, Rocchi, Vallerand, Deci, and Ryan (2013). The instrument called the "Revised Sport Motivation Scale" (SMS-II) was divided into six dimensions, with a total of 18 questions. Previous studies using SMS-II have shown a high degree of reliability and suitability for use in different sports environments (Pelletier et al., 2013; Schaefer, Vella, Allen, & Magee, 2016). The total number of items used for both instruments was 78 items.

In collecting research data, written consent must be made to the MOE. Only MOE can allow research to be conducted as this study involves students and organizations under their administration. Once the consent was obtained, the questionnaire was distributed personally by the researcher. In this case, a meeting and explanation session was conducted with respondents in the selected schools. This method is appropriate, and respondents had a fresh understanding of the objectives of the study (Hair, Black, Babin, & Anderson, 2014). It is also able to prevent the confusion of the respondent when answering the question, and the researcher can interact with all the respondents.

Results

The level of coach leadership style and football players' motivation

To assess the level of coach leadership style, mean values were used consisting of five sections, namely very high (4.21–5.00), high (3.41–4.20), medium (2.61–3.40), low (1.81–2.60) and very low (0.00–1.80). These five categories are appropriate because the instruments used in this section are on a five-point scale. Based on the study, it found that four dimensions of coach leadership style showed high levels: positive feedback, training and instruction, social consideration, and social support.

The other two dimensions were democratic and autocratic at the moderate level. Overall, the level of coach leadership style variables was high, with a mean value of 3.60, and the standard deviation was 0.48. This finding proves that football coaches in sports schools across Malaysia have adopted high-style coach leadership to train Malaysian footballers under-14. The summary formulas for each dimension of coach leadership style are shown in Table 1.

Table 1. The Level of Coach Leadership Style

Dimensions	Mean±SD	Level
Democratic	3.04±0.76	Medium
Positive Feedback	3.80±0.71	High
Training and Instruction	3.98±0.68	High
Social Consideration	3.89±0.65	High
Social Support	3.64±0.72	High
Autocratic	3.26±0.77	Medium
Overall	3.60±0.48	High

Meanwhile, football players' motivation level was also measured in this study based on the mean values divided into seven sections: very high (6.00–7.00), high (5.00–5.99), average high (4.00–4.99) medium (3.00–3.99), low (2.00–2.99) and very low (1.00–1.99), which is appropriate since the instrument used to measure football players' motivation is a seven-point scale. Based on the findings, it determined that the three dimensions of football players' motivation showed high levels: intrinsic motivation, integrated motivation, and identified motivation. The results also show that two aspects of football players' motivation are at the medium level: introjected motivation, and amotivation.

However, there is one dimension in football players' motivation at a moderate level: external motivation. When computed, the level of overall football players' motivation was medium quality with a mean value of 4.90, and the standard deviation was 0.83. The results show that under-14 football players in sports schools across Malaysia have an only moderate level of motivation. For more details, a summary of each player's motivation dimensions presented, as shown in Table 2.

Table 2. The Level of Football Players' Motivation

Dimensions	Mean±SD	Level
Intrinsic Motivation	5.47±1.29	High
Integrated Motivation	5.29±1.30	High
Identified Motivation	5.46±1.31	High
Introjected Motivation	4.91±1.38	Medium High
External Motivation	3.71±1.76	Medium
Amotivation	4.58±1.75	Medium High
Overall	4.90±0.83	Medium High

The relationship between coach leadership style and football players' motivation

The results of the study show that there is a moderate positive relationship between coach leadership style and football players' motivation, which is clearly explained in the Pearson correlation coefficient (r), in which both variables accounted for r=0.488, p=0.000 (p<0.01). This fact indicates that the motivation of the under-14 football players in sports schools across Malaysia is only modestly related to the manner or style of their coaches implementing instruction or coaching. Although the relationship is simple, it is still essential for proving the existence of a coach in improving each player's motivation.

Out of the six dimensions of coach leadership style, five showed a significant relationship with football players' motivation, as shown in Table 3. Four dimensions showed a significant and modest positive relationship with football players' motivation: positive feedback (r=0.425, p<0.01), training and instruction (r=0.499, p<0.01), social consideration (r=0.545, p<0.01), and social support (r=0.462, p<0.01). Another dimension of democratic (r=0.137, p<0.05) had a significant positive and poor relationship with football players' motivation.

However, there is one dimension that has no significant negative relationship with football players' motivation, which is autocratic leadership (r=-0.067, p>0.05), which also sug-

Table 3. The Correlation Analysis between Coach Leadership Style and Football Players' Motivation

Dimensions	Variables	Football Players' Motivation	Sig
	Coach Leadership Style	0.488**	0.00
1	Democratic	0.137*	0.02
2	Positive Feedback	0.425**	0.00
3	Training and Instruction	0.499**	0.00
4	Social Consideration	0.545**	0.00
5	Social Support	0.462**	0.00
6	Autocratic	-0.067	0.24

Legend: * - p<0.05; ** - p<0.01

gests that coaches who practice autocratic leadership styles are less comfortable with football players under-14 in sports schools across Malaysia. However, the practice of other coaches' leadership styles shows that the method is favourable and enhances player motivation. Table 3 below shows the correlation formulas between coach leadership style and football players' motivation.

The effect of coach leadership style on football players' motivation

Table 4 shows the study results generated by multiple linear regression analysis. This test was conducted to identify which dimensions of coach leadership style affect football players' motivation. Based on the adjusted R2 value of 0.317, it shows that there is a 31.7% contribution given by the dimensions of coach leadership style to football players' motivation. The input is not enormous, but it has a considerable impact on improving the motivation of football players in sports schools. Referring to the value of F=25.109 in the ANOVA analysis, it found that there was a significant difference in each dimension of coach leadership style over football players' motivation ($p<0.05$).

Table 4. The Regression Analysis between Coach Leadership Style on Football Players' Motivation

Dimensions	Beta	t	Sig.
(constant)		6.959	0.000
Democratic	-0.115	-1.995	0.047**
Positive Feedback	0.102	1.376	0.170
Training and Instruction	0.135	1.597	0.111
Social Consideration	0.307	3.414	0.001**
Social Support	0.137	1.829	0.068
Autocratic	-0.074	-1.468	0.143
R^2 value			0.330
Adjusted R^2 value			0.317
F Value			25.109
Sig.			0.000**

Based on Table 4, the findings also show that there are two dimensions of coach leadership style that contribute significantly to football players' motivation. These dimensions were democratic ($\beta=-0.115$, $p<0.05$) and social consideration ($\beta=0.307$, $p<0.05$). However, the other four dimensions showed insignificant effects ($p>0.05$): positive feedback ($\beta=0.102$, $p>0.05$), training and instruction ($\beta=0.135$, $p>0.05$), social support ($\beta=0.137$, $p>0.05$) and autocratic leadership ($\beta=-0.074$, $p>0.05$). Thus, the dimensions of coach leadership style accounted for 31.7% of the revenue from the adjusted R2 value of 0.317.

Discussion

The use of RLSS instruments (Zhang et al., 1997) and SMS-II (Pelletier et al., 2013) in this study is undoubtedly an exciting finding after the survey conducted on the respondents' aspect of Malaysia. Of interest is the fact that the respondents of the study were among the football players under the age of 14 who train in sports schools throughout Malaysia. This phenomenon makes these players closest to the coach and has a deep understanding of their coach's personality and behaviours.

As expected, the level of coach leadership style in sports schools across Malaysia is high. This is due to the growing sense of respect among young players who feel that coaches are individuals who need to be followed and followed closely (Webb et al., 2019). According to Keatlholetswe and Malete (2019), a coach is an influential individual in a team, because he or she determines the direction and fall or the rise of a team. This finding is also supported by Sullivan and Dhurup (2012), who stated that coaches are fair, transparent in guiding their players, and tolerant in their characters. Therefore, a well-respected coach will surely have the characteristics of each player under his guidance.

Meanwhile, the findings for the football players' motivation level showed inconsistent results. The dimensions of intrinsic motivation, integrated motivation and identified motivation are high. For example, Ryan and Deci (2007) stated that athletes with intrinsic motivation would do a great job when training because of their deep interest in the role. Of course, the amotivation dimension is indicative of a high-quality level as most footballers are very excited to be able to train with friends and participate in organized games (Schaefer et al., 2016). This excitement intensified when coaches were continually giving encouragement, competent guidance, and lowering their egos to understand the needs and needs of players over time (Goose & Winter, 2012).

Studies show that there is a simple correlation between coach leadership style and football players' motivation. Baric and Bucik (2009) stated that the motivation of each player varies based on the behaviour taken by a coach. A coach who has a high ego is assertive, does not care about the well-being of a player and is less likely to drop a player's motivation during training or competition. At a young age, players need constant support, guidance, and encouragement to improve their self-esteem, confidence and motivation so that their performance is at their peak (Lee & Rengasamy, 2015; Mouloud & Elkader, 2016).

It is alarming to see that only 31.7% of the dimensions in the coach leadership style contribute to football players' motivation. This contribution comprised only two significant aspects of democratic and social consideration. It is clear that when coaches have democratic behaviour, they attempt to reach out to players with low egoism, ask for players' views, and discuss possible improvements (Nazarudin et al., 2009; Noor, 2014). Clearly, Keatlholetswe and Malete (2019) state that democracy can also be practised by enhancing good relations with players in addition to effective communication methods.

Another dimension that contributes to football players' motivation is social consideration. As previously explained, coaches are rational human beings and are caring toward their players (Chelladurai, 1980). This behaviour is very comforting to young footballers, especially those who are far from family. Loving, parenting, caring, aware of health issues and personal issues are the most praiseworthy behaviours that every coach should have (Kucukibis & Gul, 2019)were doing three individuals sports (table tennis, weight lifting, judo. It makes football players more motivated when they know they are not only well cared for but loved.

Football is not just an entertaining game: it is a sport that brings unity. Regardless of age, race or gender, the sport of football has a huge fan base. When asked, children say they want to be football players, as they grow up to be their idols. With players' high salaries and being recognized all over the world, these children must be excited to work, play ball in their hometown or location and embark on their dream of becoming a leading football star. Names like Cristiano Ronaldo, Lionel Messi and Neymar have always led to their dreams at night.

It is very fortunate for the players at MSS and SSS to be selected to practice and seek intensive and systematic guidance. All of them are a national asset of choice among primary school students whose talents have been featured in previous tournaments. At the age of 14, these groups need to be formed, raised, and given proper guidance so that their potential and talent can be polished and shine one day. With the concept of structured training, adequate time management and nutrition according to the pyramid system provided, these young players can stand out and even shine on the higher stage. Although it would be a bit much to put the World Cup on target, it is still a privilege among Asian nations that it is realistic for them to lift Malaysia's name in the world of football.

Acknowledgements
This study is fully sponsored by the Ministry of Education Malaysia (MOE), under the Federal Training Gift Program.

Conflict of interest
The authors declare that there are no conflicts of interest.

Received: 19 April 2020 | **Accepted:** 21 June 2020 | **Published:** 01 February 2021

References

Amara, M. (2017). Football in West Asia. In J. Hughson, K. Moore, R. Spaaij, & J. Maguire (Eds.), *Handbook of football studies*. Oxon, UK: Taylor & Francis.

Baric, R., & Bucik, V. (2009). Motivational differences in athletes trained by coaches of different motivational and leadership profiles. *Journal Kinesiology*, *41*(2), 181–194.

Carroll, G. (2019). *Talent identification in football: an exploratory study from the scouts perspective*. Unpublished Undergraduate Thesis. West Sussex, England: University of Chichester.

Chelladurai, P. (1980). Leadership in sport organizations. *Canadian Journal of Applied Sport Sciences*, *5*, 226–231.

Cho, Y. (2015). *Football in Asia: History, culture and business*. Oxon, UK: Taylor & Francis.

Din, A., Rashid, S. A., & Awang, M. I. (2015). Aspek pengurusan program latihan dan kesannya terhadap kepuasan atlet sekolah sukan. *International Journal of Management Studies*, *22*(1), 73–95.

Dyakova, G., Dyakov, T., & Angelova, I. (2017). Study of the students' interest in the football game, motivation and desire for practicing football. *Trakia Journal of Science*, *15*(1), 375–382. https://doi.org/10.15547/tjs.2017.s.01.063

FIFA. (2020). Coca-cola men's world ranking. Retrieved April 10, 2020, from https://www.fifa.com/fifa-world-ranking/ranking-table/men/

Goose, M., & Winter, S. (2012). The coach's impact on long distance runners' training and competition motivation. *International Journal of Sports Science and Coaching*, *7*(2), 383–398. https://doi.org/https://doi.org/10.1260/1747-9541.7.2.383

Govindan, J. K., Geok, S. K., Yusof, A., & Omar-Fauzee, M. S. (2019). Persepsi atlet terhadap gaya tingkah laku kepimpinan jurulatih bola sepak sekolah yang digemari dengan gaya tingkah laku kepimpinan sebenar jurulatih bola sepak di daerah Alor Gajah, Melaka. *Malaysian Journal of Movement, Health & Exercise*, *8*(1), 123–133. https://doi.org/https://doi.org/10.15282/mohe.v8i1.276

Hair, J. J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2014). *Multivariate data analysis* (7th ed.). Essex: Pearson Education Limited.

Keatlholetswe, L., & Malete, L. (2019). Coaching Efficacy , Player Perceptions of Coaches ' Leadership Styles , and Team Performance in Premier League Soccer. *Research Quarterly for Exercise and Sport*, *00*(00), 1–9. https://doi.org/10.1080/02701367.2018.1563277

Krejcie, R. V, & Morgan, D. W. (1970). Determining sample size for research activities. *Educational and Psychological Measurement*, *38*(1), 607–610. https://doi.org/10.1177/001316447003000308

Kucukibis, H. F., & Gul, M. (2019). Study on sports high school students' motivation levels in sports by some variables. *Universal Journal of Educational Research*, *7*(3), 839–847. https://doi.org/10.13189/ujer.2019.070325

Lee, W. A. S. S., & Rengasamy, S. A. (2015). Gaya kepimpinan jurulatih yang diminati atlet-atlet sekolah menengah di Malaysia berasaskan jantina. *Jurnal Kepimpinan Pendidikan*, *3*(1), 32–46.

Lescroart, M. A. Y., Brown, M. E., & Paskus, T. S. (2015). The relationship between ethical and abusive coaching behaviors and student-athlete well-being. *Sport, Exercise, and Performance Psychology*, *4*(1), 36–49. https://doi.org/10.1037/spy0000023

Mouloud, K., & Elkader, B. A. (2016). Self-efficacy and achievement motivation among football player. *The Swedish Journal of Scientific Research*, *3*(11), 13–19.

Nazarudin, M. N., Omar-Fauzee, M. S., Jamalis, M., Geok, S. K., & Din, A. (2009). Coaching leadership styles and athlete satisfaction among Malaysian University basketball team. *Research Journal of International Studies*, *9*(January), 4–11.

Noor, N. M. (2014). *Hubungan tingkah laku kejurulatihan dengan motivasi atlet bola sepak di sekolah sukan Malaysia*. Unpublished Master Dissertation. Selangor, Malaysia: Universiti Putra Malaysia.

Pelletier, L. G., Rocchi, M. A., Vallerand, R. J., Deci, E. L., & Ryan, R. M. (2013). Validation of the revised sport motivation scale (SMS-II). *Psychology of Sport and Exercise*, *14*(3), 329–341. https://doi.org/10.1016/j.psychsport.2012.12.002

Rosly, J. (2019). MOM cadang bida Sukan Asia 2030. *Berita Harian*. Retrieved from https://www.bharian.com.my/sukan/lain-lain/2019/03/540608/mom-cadang-bida-sukan-asia-2030

Ryan, R. M., & Deci, E. L. (2007). Active human nature. In M. S. Hagger & N. L. Chatzisarantis (Eds.), *Intrinsic motivation and self-determination in exercise and sport* (pp. 1–19). Champaign, IL: Human Kinetics.

Schaefer, J., Vella, S. A., Allen, M. S., & Magee, C. A. (2016). Competition anxiety, motivation, and mental toughness in golf. *Journal of Applied Sport Psychology*, *21*(10), 1475–1483.

Sullivan, J., & Dhurup, M. (2012). The relation of coaching context and coach education to coaching efficacy and perceived leadership behaviors in youth sport. *Sport Psychologist*, *26*(1), 122–130.

Webb, T., Dicks, M., Brown, D. J., & O'Gorman, J. (2019). An exploration of young professional football players' perceptions of the talent development process in England. *Sport Management Review*, *In Press*, 1–12. https://doi.org/https://doi.org/10.1016/j.smr.2019.04.007

Zhang, J., Jensen, B. E., & Mann, B. L. (1997). Modification and revision of the Leadership Scale for Sport. *Journal of Sport Behavior*, *20*(1), 105–122.

DOI 10.26773/smj.210220

ORIGINAL SCIENTIFIC PAPER

Differences in Anthropometric Characteristics and Body Composition of Water Polo Players in the 2019 World Junior Championship

Ivan Vasiljevic[1], Marko Aleksandrovic[2], Marin Corluka[3] and Eldin Jeleskovic[4]

[1]University of Montenegro, Faculty for Sport and Physical Education, Niksic, Montenegro, [2]University of Nis, Faculty of Sport and Physical Education, Nis, Serbia, [3]University of Mostar, Faculty of Mathematics and Science Education, Mostar, Bosnia and Herzegovina, [4]University of Sarajevo, Faculty of Sport and Physical Education, Sarajevo, Bosnia and Herzegovina

Abstract

This research aimed to determine the differences between the junior (U20) water polo players of national teams of Montenegro, and Australia regarding their anthropometric characteristics and body composition. The first sub-sample of the subjects consisted of 18 water polo players of the Montenegrin national team, who occupied the sixth position on the FINA World Men's Junior Water Polo Championship in Kuwait 2019. The second sub-sample consisted of 13 water polo players of the Australian national team, who occupied the eleventh position on the championship. The players were tested at the final preparations just before the World Championship. Anthropometric characteristics were evaluated using a battery of eight tests: body height, body weight, triceps skinfold, biceps skinfold, skinfold of the back, abdominal skinfold, upper-leg skinfold, lower leg skinfold; body composition was evaluated using a battery of three tests: body mass index, fat percentage, and muscle mass. The results of the t-test revealed that the water polo players of the two national teams do not have statistically significant differences in the variables. The results obtained in this research showed average team values for the estimated variables of water polo players of the two national teams (U20) who participated in the World Championship. That can serve as possible model parameters for all teams who want to participate in the U20 water polo World Championship. Differences in classification among water polo players may be related to the motor abilities, as well as technical and tactical parameters, as their anthropometric parameters were found to be similar.

Keywords: *junior water polo players, body composition of water polo players, anthropometric characteristics of water polo players*

Introduction

Water polo is a popular sport worldwide. It is a highly dynamic and fast team game that, with its abundance of movement, is in the category of polystructural sports games. Water polo is a sport characterized by numerous complex and dynamic kinesiological activities, which are then characterized by either cyclical or acyclical movement. It is contact sport (Cecchi et al., 2019), characterized by different swimming intensities, duelling, acceleration and deceleration (Gardasevic et al., 2019; Gardasevic et al., 2020). In water polo, top results can be achieved only within a well-programmed training process. High quality management of the training process depends on knowing the structure of certain anthropological capabilities and water polo players' characteristics, as well as their development. Findings regarding anthropometric characteristics and body composition are crucial for complex sports, such as water polo. The anthropometric space is defined by the longitudinal dimension of the skeleton, the transversal dimensionality of the skeleton, and the mass and volume

Correspondence:

M. Aleksandrovic
University of Nis, Faculty of Sport and Physical Education, Carnojevica 10A, 18000 Nis, Serbia
E-mail: aleksandrovic@fsfv.ni.ac.rs

of the body. The purpose of knowing anthropometric characteristics is to improve skills in many sports (Gardasevic et al., 2019; Gardasevic et al., 2019; Masanovic et al., 2018). The anthropometric status of top-level athletes is relatively homogeneous, depending on the sport, and can be defined as a model of athletic achievement (Gardasevic et al., 2020). Research on anthropometric characteristics and body composition among athletes of different sports indicates that athletes of different sports have specific characteristics (Gardasevic et al., 2020; Masanovic, 2018; Masanovic et al., 2021; Arifi et al., 2019; Popovic et al., 2013), mostly because the size of those characteristics contributes a significant percentage of total variance associated with athletic success (Carvajal et al., 2012). Muscle mass improves performance in activities that require muscular strength and endurance, as well as those that require enviable aerobic ability (Rico-Sanz, 1998).

It is well known that water polo in Montenegro and Australia has a long tradition and the best results in international competitions, especially Montenegro. Montenegrins were the junior world champions, and Australians were vice-champions once. Montenegro's junior national team is always top-ranked in Europe and the world.

It was expected that the national teams, especially Montenegrins, would continue with good results on the FINA World Men's Junior (U20) Water Polo Championship in Kuwait 12–20 December 2019, where twenty national teams participated. It is clear that these were the best players in Montenegro and Australia, at age 20, and that they had many years of quality training to qualify to wear a representative cap. It is well known in all sports and, therefore, in water polo that long-term and intensive training is a critical factor that enables athletes to reach and remain at the elite representative level (Gardasevic et al., 2019). Researchers became interested in determining the models of anthropometric characteristics and body composition of the water polo players who play for these two national teams in order to determine the differences among them.

This research aimed to determine the anthropometric characteristics and body composition of junior (U20) water polo players of national teams of Montenegro and Australia, who participated on the FINA World Men's Water Polo Championship 2019 in Kuwait. The variables between these water polo players were compared, and the possible differences between them were determined.

Methods

Sample of subjects

A sample of the subjects consists of 31 water polo players, divided into two sub-samples. The first sub-sample of the subjects consisted of 18 water polo players of the national team of Montenegro of an average age of 18.44±0.98, who occupied the sixth position on the championship. The second sub-sample consisted of 13 water polo players of the national team of Australia of an average age of 19.00±0.91, who occupied the eleventh position on the World Men's Junior Championship (Table 1).

Players of the Montenegrin and Australian national teams were tested at the final joint preparations in Niksic (Montenegro), one week before the World Championship. Because they were in the final pre-championship preparations, the final list of players was not formed (possibility of injuries or illness are why there is often a surplus of players), and the number of players tested was different among teams. All participants signed the consent form approved by the Institutional Review Board of the University of Montenegro, which was in accordance with the Declaration of Helsinki as amended by the World Medical Association Declaration of Helsinki (World Medical Association, 2013).

Table 1. Final rankings (20 December 2019) at the FINA World Men's Junior Water Polo Championship in Kuwait 2019

National teams	Place
Greece	1
Serbia	2
Italy	3
Croatia	4
Spain	5
Montenegro	**6**
USA	7
Japan	8
Hungary	9
Canada	10
Australia	**11**
New Zealand	12
Russia	13
South Africa	14
Egypt	15
China	16
Brazil	17
Uzbekistan	18
Iran	19
Kuwait	20

Sample of variables

Anthropometric research has been carried out with respect to the basic rules and principles related to the selection of measuring instruments and measurement techniques, standardized in accordance with the International Biological Program guidelines. For this study, eight anthropometric measures were taken: body height, body weight, triceps skinfold, biceps skinfold, skinfold of the back, abdominal skinfold, upper leg skinfold and lower leg skinfold, as well as three body composition assessment variables: body mass index, fat percentage and muscle mass. An anthropometer, calliper, and measuring tape were used for anthropometric measurements. To evaluate the body composition and body weight, a Tanita body fat scale (model BC-418MA) was used. The scale is based on the indirect measurement of the body composition; a safe electrical signal is transmitted through the body via electrodes located in the standalone unit. The Tanita Scale enables athletes to closely monitor their body weight, body mass index, fat percentage, fat mass, muscle mass, and bone mass; it also provides a segmental analysis of arms and legs.

Statistical analysis

The data obtained through the research were processed using descriptive and comparative statistical procedures. For each variable, central and dispersion parameters have been processed. The significance of the differences between the water polo players of the two national teams in the anthropometric characteristics and variables for assessing body composition was determined using a t-test, with statistical significance of $p<0.05$ using IBM SPSS Statistics 20.0

Results

In Tables 2 and 3, basic descriptive statistical parameters of variables of anthropometric characteristics and body composition of the Montenegrin and Australian water polo players are shown. First, the central and dispersion parameters of the variables of the water polo players of Montenegro were analysed (Table 2).

Table 2. Central and dispersion parameters of variables for the assessment of anthropometric characteristics and body composition of Montenegrin Water polo players (N=18)

Variables	Min	Max	Mean±SD	Skewness	Kurtosis
body height	178.0	201.3	189.60±6.90	.173	-.802
body weight	67.1	117.5	88.69±11.72	-.012	-.550
triceps skinfold	4.3	12.4	7.85±2.38	.566	1.004
biceps skinfold	3.2	9.6	6.35±1.86	.444	-1.092
skinfold of the back	7.8	18.1	12.11±3.31	-.061	-.962
abdominal skinfold	5.8	31.4	16.01±7.45	.312	-.778
upper leg skinfold	6.8	23.0	13.21±4.25	.604	-.682
lower leg skinfold	5.2	16.5	9.96±3.54	.805	.088
body mass index	20.3	29.0	24.59±2.20	.499	-.928
fat percentage	5.5	22.5	13.13±4.39	.048	.170
muscle mass	34.4	54.6	43.47±4.75	.234	-.362

Legend: Min - minimum result; Max - maximum result; SD – standard deviation

Based on the central and dispersion parameters, and the values of the skewness and the kurtosis, it can be noted that all the variables are within the normal distribution boundaries. Generally, according to all statistical parameters, it can be concluded that this is a good selection of Montenegrin water polo players U20, that there is a normal distribution in almost all variables, and that the results that prevail are superior to the arithmetic mean, which is not statistically significant because not too large a span between the results of analysed variables is to be expected regarding water polo national team members.

Table 3. Central and dispersion parameters of variables for the assessment of anthropometric characteristics and body composition of Australian water polo players (N=13)

Variables	Min	Max	Mean±SD	Skewness	Kurtosis
body height	182.5	202.0	191.27±5.5173	.286	-.176
body weight	73.3	102.6	89.06±8.1556	-.391	.006
triceps skinfold	4.8	17.0	8.88±3.2046	1.249	2.545
biceps skinfold	3.6	17.9	7.04±3.8675	1.419	1.361
skinfold of the back	7.8	16.0	11.73±3.5436	.626	-.852
abdominal skinfold	4.0	34.6	13.50±8.2407	1.557	2.801
upper leg skinfold	7.4	19.0	11.79±4.1570	.895	-.735
lower leg skinfold	4.0	14.8	9.462±3.4973	.077	-.974
body mass index	21.5	28.5	24.35±1.9797	.867	.372
fat percentage	6.8	20.9	11.31±4.0305	1.241	1.601
muscle mass	38.2	48.2	44.61±3.2602	-1.117	.554

Based on the central and dispersion parameters of the Australian water polo players (Table 3), it can be stated that the values all the variables are very similar to those of the Montenegrin water polo players.

By the value of the skewness, it can be observed that in the variables of the triceps skinfold, biceps skinfold, abdominal skinfold, and fat percentage there was a slight inclination on the side of the lower results, which is beneficial for athless because subcutaneous fat is a disruptive factor. In the case of muscle mass is opposite. There was a slight inclination on the side of the better results. The values of the kurtosis of variables of the biceps skinfold and fat percentage form a slight leptokurtic curve, while two variables of the triceps skinfold and abdominal skinfold, form a significant leptokurtic curve.

To determine whether there are statistically significant differences in the analysed variables in the Montenegrin and Australian water polo players, participants of World Championship 2019 in Kuwait, the statistical procedure t-test (Table 4) was applied.

Table 4. T-test values between of variables of water polo players of Montenegrin national team (N=18) and of Australian national team (N=15)

Variables	National team	Mean±SD	Mean Diff.	t-test	Sig.
body height	Montenegro	189.60±6.90	-1.67	-.721	.477
	Australia	191.27±5.52			
body weight	Montenegro	88.69±11.72	-0.37	-.099	.922
	Australia	89.06±8.15			
triceps skinfold	Montenegro	7.85±2.38	-1.03	-1.034	.310
	Australia	8.88±3.20			
biceps skinfold	Montenegro	6.35±1.86	-0.69	-.660	.514
	Australia	7.04±3.87			
skinfold of the back	Montenegro	12.11±3.31	0.38	.307	.761
	Australia	11.73±3.54			
abdominal skinfold	Montenegro	16.01±7.45	2.51	.883	.384
	Australia	13.50±8.24			
upper leg skinfold	Montenegro	13.21±4.25	1.42	.922	.364
	Australia	11.79±4.16			
lower leg skinfold	Montenegro	9.96±3.54	0.50	.385	.703
	Australia	9.46±3.49			
body mass index	Montenegro	24.59±2.20	0.24	.316	.754
	Australia	24.35±1.98			
fat percentage	Montenegro	13.13±4.39	1.82	1.173	.250
	Australia	11.31±4.03			
muscle mass	Montenegro	43.47±4.75	-1.14	-.747	.461
	Australia	44.61±3.26			

Based on the t-test results (Table 4), it can be stated that the values of all the variables are very similar to all water polo players of these two countries. There were no significant differences in variables among the water polo players of the two national teams.

Discussion

This study aimed to determine the difference in the anthropometric characteristics and body composition of the junior (U20) water polo players of the Montenegrin national team, who occupied the sixth position, and the water polo players of the Australian national team, who occupied the eleventh position at the FINA World Water Polo Championship in Kuwait, 12–20 December 2019. The results were obtained using a battery of eight tests regarding anthropometric characteristics and three tests regarding body composition. By examining the basic descriptive statistical parameters, we have analysed the best selected junior age water polo players from these countries. Similar results in their research were obtained by Kondric, Uljevic, Gabrilo, Kontić, and Sekulić (2012). They found some lower body height 186.92 cm, and lower body weight 84.31 kg, in the sample of the 110 best world water polo players, in comparison to water polo players from our research, but it was at the age of 18 years, when growth and development are not finished. Having that in mind, we can say that those of U20 reached similar results as water polo players who were the subject of this research. When we compare water polo players of these two national teams with some other athletes, for example, football players of the same age (Gardasevic & Bjelica, 2020), we can observe differences in anthropometric characteristics and body composition, which speaks in favour of the specificity of each sport in terms of new variables. It can be noted that the water polo players are taller and have a lower body weight than U19 football players in Montenegro (body height=179.01 cm; body weight=69.58 kg) in Bosnia and Hercegovina (body height=180.99 cm; body weight=73.65 kg) or in Kosovo (body height=178.15 cm; body weight=70.34 kg) (Gardasevic & Bjelica, 2020). A difference in fat percentage is also observed; with football players in Montenegro it is 9.88%, in Bosnia and Hercegovina 9.65%, and in Kosovo it is 8.66% (Gardasevic and Bjelica, 2020). These are lower values in comparison to water polo players of two national teams. However, muscle mass is more dominant with water polo players, and it is in average 8-9 kg on a higher level than it is with football players from the two mentioned countries from the research of Gardasevic and Bjelica (2020).

It can be observed that the water polo players of the Montenegrin and Australian national teams are of the approximately similar mean values of all the variables analysed, which is not surprising because these are two national teams of the same age, from countries where water polo is popular and where water polo coaches are highly skilled. If we analyse the final achievements at the championship, then we could say that the absence of these differences is a surprise. Nevertheless, a final result at some competition is affected by many other things, such as physical preparation, technical and tactical preparation psychological preparation, that fact that all players are without injuries and penalties, than good timing of form in the championship, and similar factors.

U20 water polo players have years of training experience and spend many hours in the pool each week. The t-test results displayed that the water polo players of Montenegrin and Australian national team do not differ significantly in the analysed variables. For all variables, some values are higher for water polo players of the Montenegrin national team (skinfold of the back, abdominal skinfold, upper leg skinfold, lower leg skinfold and body mass index) and some for those of the Australian national team (body height, body weight, triceps skinfold, biceps skinfold, fat percentage and muscle mass), although, insignificantly for statistics. All of the abovementioned indicates that water polo players of the Montenegrin and Australian national team have similar anthropometric parameters and body compositions. All of these players have long-term training before significant competitions, and they are all among best water polo players in the world level, so it is not surprising that there are no differences in anthropometric characteristics and body composition between them. Due to their lifestyle (constant training and sports nutrition), all top athletes take care of body composition; this is confirmed in the research of Melchiorri et al. (2018), which found no differences in body weight and body composition in 13 water polo players after a three-month training programme for the Olympic Games. Using the system of bioelectrical impedance for high-level athletes involved in long and intense training periods helps to evaluate the effects of training and to prevent any decrease in the performance level of body composition (Melchiorri et al., 2018).

Given that the concentration of the best water polo players U20 is at World Championship in Kuwait 2019, the assumption is that the mean values of the analysed variables of two national teams' water polo players should be the model values for all such clubs in the world. Of course, it is clear that these are the team average values of analysed variables, and that the different positions which water polo players cover as well as their differences in stated variables in relation to these positions were not taken into consideration.

Based on the results obtained in this research, before the start of the World Championship, it could not be assumed which national team would achieve a better placement. The Kuwait Championships showed that they were the national teams in which the nuances decided the final standings. For example, the Montenegrin national team in the quarter-finals lost with one goal difference to the Serbian national team in the last minute of the game, and thus lost their chance for the medal fight. In the finals, the Serbian national team lost to the Greek national team by a small result and thus won a silver medal. After the defeat of the Serbian national team, the Montenegrin national team fought for 5th to 8th place (winning 6th place). All this confirms that these are the best water polo players in the world under the age of 20, many of whom already play for the senior national teams.

All water polo players of the two national teams had similar levels of subcutaneous adipose tissue. Different authors state the importance of body fat as a positive fact in water polo (Platanou, 2005; Peric et al., 2012); however, in other studies, it is not confirmed (Vila et al., 2018), and many researchers have demonstrated that it is a disruptive factor for athletes (Masanovic, 2019; Milanovic & Vuleta, 2013). Also, in previous studies of water polo players of this age, subcutaneous adipose tissue has been shown to be a disruptive factor in defence (Milanovic, & Vuleta, 2013). It is well known that a low fat percentage is desirable for high physical performance in all sports. Although not every body composition characteristic is expected to play a role in optimal performance in professional sport, lower levels of body fat (that are specific to each player) are desirable for optimal performance, as body mass must be moved against gravity (Rienzi et al., 2000; Gil et al., 2007).

All the water polo players of the Montenegrin and Australian national teams had similar muscle mass values; water polo is a strenuous sport that takes place in water and requires significant muscle mass. Body height is important for swimming. The Montenegrin nation is among the tallest in Europe and the world with an average body height of male of 183.2 cm (Gardasevic et al., 2017), and Montenegrin water polo players in this study are 189.6 cm tall, which speaks in favour of the importance of body height for water polo. Long arms are important for kicks and defence; however, there were no statistically significant differences between the water polo players of the two national teams, which is perhaps surprising, considering that the Montenegrin national team dropped out in the quarter-final of the competition, and the Australian national team did not qualify for the quarter-final of the World U20 Championship. The reason for the different placement may be found in the different levels of technical and tactical preparation, and functional and psychological preparation between water polo players of the two teams. Physical preparation at such championships is essential because it is done every day, and we have not analysed it. Experience in playing deciding matches at this level of competition can be the reason for different placement. The Montenegrin team has more experience than the Australian team does.

The national water polo associations of Montenegro and Australia should turn to other research studies and check the functional-motoric status, psychological preparation as well as tactical training of their players, and analyse whether there are differences at water polo players that influenced the result at this world championship, and whether there is room for improvement. The values obtained in this research can be useful for coaches of these national teams to compare their players with others and prepare their work in a way that enables the reduction of adverse parameters and raises the beneficial ones to a higher level. That will surely make their water polo players even better and more successful. The results obtained in this research can serve as model parameters for the estimated variables for water polo players (U20) of all clubs in Montenegro and Australia, because the players that have been analysed were the best and the most successful water polo players in their countries, and participants in the World Championship in Kuwait 2019.

Acknowledgements
The authors wish to thank the members of the Water Polo Association of Montenegro and Australia for their cooperation.

Conflicts of Interest
The authors declare that there are no conflicts of interest.

Received: 24 May 2020 | **Accepted:** 17 July 2020 | **Published:** 01 February 2021

References

Arifi, F., Bjelica, D., & Masanovic, B. (2019). Differences in anthropometric characteristics among junior soccer and handball players. *Sport Mont, 17*(1), 45-49.

Carvajal, W., Betancourt, H., León, S., Deturnel, Y., Martínez, M., Echevarría, I., et al. (2012). Kinanthropometric Profile of Cuban Women Olympic Volleyball Champions. *MEDICC Review, 14*(2), 16-22. doi: 10.1590/s1555-79602012000200006

Cecchi, N.J., Monroe, D.C., Fote, G.M., Small, S.L., & Hicks, J.W. (2019). Head impacts sustained by male collegiate water polo athletes. *PLoS ONE, 14*(5), e0216369. https://doi.org/10.1371/journal.pone.0216369

Gardasevic, J., Rasidagic, F., Krivokapic, D., Corluka, M., & Bjelica, D. (2017). Stature and Its Estimation Utilizing Arm Span Measurements in Male Adolescents from Federation of Bosnia and Herzegovina Entity in Bosnia and Herzegovina. *Montenegrin Journal of Sports Science and Medicine, 6*(1), 37–44.

Gardasevic, J., Bjelica, D., Corluka, M., & Vasiljevic, I. (2019). Elite football players from Bosnia and Herzegovina and Kosovo and their body composition. *Sport Mont, 17*(2), 75-79. doi: 10.26773/smj.190613

Gardasevic, J., Bjelica, D., & Vasiljevic, I. (2019). Morphological characteristics and body composition of elite soccer players in Montenegro. *International Journal of Morphology, 37*(1), 284-288.

Gardasevic, J., Akpinar, S., Popovic, S., & Bjelica, D. (2019). Increased Perceptual and Motor Performance of the Arms of Elite Water Polo Players. *Applied Bionics and Biomechanics*, 6763470. doi: 10.1155/2019/6763470.

Gardasevic, J., Bjelica, D., Vasiljevic, I., Arifi, F., & Sermaxhaj, S. (2019). Body composition of elite soccer players from Montenegro and Kosovo. *Sport Mont, 17*(3), 27-31. doi: 10.26773/smj.191011

Gardasevic, J., & Bjelica, D. (2020). Body composition differences between football players of the three top football clubs. *International Journal of Morphology, 38*(1), 153-158.

Gardasevic, J., Bjelica, D., & Vasiljevic, I. (2020). Differences in body composition between water polo players of national teams of Montenegro and Croatia participating in the European U15 Championship 2019. *International Journal of Morphology*, *38*(3), 720-725.

Gardasevic, J., Bjelica, D., Vasiljevic, I., Corluka, M., Arifi, F., & Sermaxhaj, S. (2020). Differences in body composition between young football players of football clubs in Montenegro, Bosnia and Kosovo. *Kinesiologia Slovenica*, *26*(1), 27-32. ISSN: 1318-2269.

Gardasevic, J., Bjelica, D., Vasiljevic, I., Corluka, M., Arifi, F., & Sermaxhaj, S. (2020). Morphological characteristics and body composition of the winners of the soccer cup of Bosnia and Herzegovina and Kosovo. *Sport Mont, 18*(1), 103-105. doi: 10.26773/smj.200219

Gil, S.M., Gil, J., Ruiz, F., Irazusta, A., & Irazusta, J. (2007). Physiological and anthropometric characteristics of young football players according to their playing position: relevance for the selection process. *J. Strength Cond. Res., 21*, 438-45.

Kondric, M., Uljevic, O., Gabrilo, G., Kontić, D., & Sekulić, D. (2012). General anthropometric and specific physical fitness profile of high-level junior water polo players. *Journal of human kinetics, 32*, 157–165. doi:10.2478/v10078-012-0032-6

Masanovic, B. (2018). Comparative study of anthropometric measurement and body composition between junior basketball and volleyball players from Serbian national league. *Sport Mont, 16*(3), 19-24.

Masanovic. B., Corluka, M., & Milosevic, Z. (2018). Comparative Study of Anthropometric Measurement and Body Composition of Junior Soccer and Handball Players from the Serbian National League. *Kinesiologia Slovenica, 24*(3), 37-46.

Masanovic, B. (2019). Comparative study of morphological characteristics and body composition between different team players from Serbian junior national league: soccer, handball, basketball and volleyball. *International Journal of Morphology, 37*(2), 612-9.

Masanovic, B., Gardasevic, J., & Bjelica, D. (2021). Comparative study of anthropometric measurement and body composition between elite handball and volleyball players from the Serbian national league. *International Journal of Morphology*, *39*(1), 287-293.

Melchiorri, G., Viero, V., Sorge, R., Triossi, T., Campagna, A., Volpe, S.L., Lecis, D., Tancredi, V., & Andreoli, A. (2018). Body composition analysis to study long-term training effects in elite male water polo athletes. *The Journal of Sports Medicine and Physical Fitness, 58*(9), 1269-74 doi: 10.23736/S0022-4707.17.07208-5

Milanovic, D., & Vuleta, D. (2013). Association between morphological dimensions of water polo players and play performance indicators. *Sport Mont, XI*(37-39), 447-453.

Peric, M., Zenic, N., Mandic, G.F., Sekulic, D., & Sajber, D. (2012). The reliability, validity and applicability of two sport-specific power tests in synchronized swimming. *J Hum Kinet, 32*, 135-45.

Platanou, T. (2005). On-water and dryland vertical jump in water polo players. *J Sports Med Phys Fitness, 45*(1), 26-31.

Popovic, S., Akpinar, S., Jaksic, D., Matic, R., & Bjelica D. (2013). Comparative Study of Anthropometric Measurement and Body Composition between Elite Football and Basketball Players. *International Journal of Morphology, 31*(2), 461-467.

Rico-Sanz, J. (1998). Body composition and nutritional assessments in football. *International Journal of Sport Nutrition, 8*, 113-123.

Rienzi, E., Drust, B., Reilly, T., Carter, J.E.L., & Martin, A. (2000). Investigation of anthropometric and work-rate profiles of elite South American international football players. *J Sports Med Phys Fitness, 40*(2), 162-169.

Vila, M.H., Manchado, C., Abraldes, J.A., & Ferragut, C. (2018). Predicting playing status in professional water polo players: analysis by gender. *The Journal of Sports Medicine and Physical Fitness, 58*(9), 1234-9.

World Medical Association (2013). World Medical Association Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Subjects. *The Journal of the American Medical Association, 310*(20), 2191–2194. doi:10.1001/jama.2013.281053

DOI 10.26773/smj.210207

REVIEW PAPER

Physical Activity, Ketogenic Diet, and Epilepsy: A Mini-Review

Maria Ruberto[1], Vincenzo Monda[2], Francesco Precenzano[3], Girolamo Di Maio[4], Antonietta Messina[2], Valentina Lanzara[3], Eugenio Merolla[3], Nicola Tartaglia[5], Antonio Ambrosi[5], Marcellino Monda[2], Cristian V. Francavilla[6], Giovanni Messina[7], Fiorenzo Moscatelli[7]

[1]Centro Minerva pro-Juventute, Naples, Italy, [2]University of Campania Luigi Vanvitelli, Department of Experimental Medicine, Section of Human Physiology and Unit of Dietetic and Sport Medicine, Naples, Italy, [3]University of Campania Luigi Vanvitelli, Department of Mental Health, Physical and Preventive Medicine, Clinic of Child and Adolescent Neuropsychiatry, Naples, Italy, [4]University of Naples Federico II, Department of Experimental Medicine, Naples, Italy, [5]University of Foggia, Department of Medical and Surgical Sciences, Foggia, Italy, [6]University of Enna "Kore", Enna, Italy, [7]University of Foggia, Department of Clinical and Experimental Medicine, Foggia, Italy

Abstract

One-third of patients with epilepsy do not respond to antiepileptic drugs and may seek complementary and alternative treatment modalities. Dietary therapies, such as the ketogenic diet (KD), the modified Atkins diet, as well as the medium-chain triglyceride and the low glycaemic index diets, have been successfully implemented with some forms of epilepsy and are growing in utilization. The KD is a high-fat, low-protein, low-carbohydrate diet that has been used for various conditions for over a century. Insights into the mechanism of action of these diets may provide more targeted interventions for patients with epilepsy. Knowledge of these mechanisms is growing and includes neuroprotective effects on oxidative stress, neuroinflammation, potassium channels in the brain, and mitochondrial function. In this review, we explain the role of physical exercise and the ketogenic diet on epilepsy.

Keywords: *ketogenic diet, physical exercise, epilepsy*

Introduction

Movement is essential for physical and neurocognitive development, ensuring correct growth and giving many benefits from childhood to adulthood. In general, motor activity plays a pivotal role in psychological, educational, and social terms. Indeed, sport practice induces harmonious physical development with common significant benefits, independent of sport type. In contrast, each sport imposes rules that children learn to know and respect step-by-step, improving their social skills and cognitive abilities, because regular physical exercise has been demonstrated to beneficially affect neural health and function and reduce the risk of various neurological diseases (Monda et al., 2017a).

The practise of physical activity by subjects with epilepsy has been a matter of debate for health professionals dealing with this disease, and of concern for the patients themselves, as well as families and caregivers. A question frequently asked is if exercise could result in an increase in seizures. As physicians themselves were unable to properly counsel, they have been discouraged from participating in physical activities or sports. Persons with epilepsy must deal with many social and cultural stigmas, and restricting physical activity contributes to further limitations to normal and healthy living (Pimentel, Tojal, & Morgado, 2015).

Epilepsy is a common and prevalent neurologic disease found in 2% of the population, affecting people of all ages and characterized by a predisposition to seizures as well as neurobiological, psychological, cognitive, and social consequences (Scheffer et al., 2018). Due to their condition, patients with epilepsy may develop other medical problems, such as heart dis-

Correspondence:

G. Messina
University of Foggia, Department of Clinical and Experimental Medicine, Viale L. Pinto 1, 7122 Foggia, Italy
Email: giovanni.messina@unifg.it

ease, cognitive decline or dementia, insulin resistance, obesity, atherosclerosis, and internalizing problems, such as anxiety and depression (Fisher et al., 2014). Commonly, individuals with epilepsy tend to have a sedentary lifestyle, which leads to poor physical fitness (Capovilla, Kaufman, Perucca, Moshé, & Arida, 2016).

Consequently, individuals with epilepsy have low levels of maximal oxygen uptake and cardiorespiratory fitness and reduced levels of strength and flexibility. The lower aerobic fitness observed in people with epilepsy may be associated with their sedentary habits (Rauchenzauner et al., 2017). Physical activity should be encouraged in this group, as previous studies have reported several positive effects of physical exercise in people with epilepsy. However, the correct management and prescription of physical exercise programmes in epilepsy patients depend on health professionals' knowledge(A. Olivares, G. Olivares, Mula, Górriz, & Ramírez, 2011).

People with epilepsy (PWEs) have often been advised against participating in sports and exercise, mostly because of fear, overprotection, and ignorance about the benefits and risks associated with such activities (Tsuji, 2017). Although the implications of engaging in sports and physical exercise for PWEs have been extensively debated, several studies reported that in most cases these activities can have a beneficial influence on seizure frequency and severity (Pimentel et al., 2015). As a result, attitudes regarding sports and epilepsy have changed considerably in recent decades, as have recommendations in clinical practice (K.R. Kaufman, & N.D. Kaufman, 2013).

Epileptic events can be managed with a ketogenic diet, although it is by no means clear how ketone bodies regulate neuronal events in the brain to control the episodes. The brain utilises ketone bodies as an energy source rather than glucose with this type of diet. Many studies have been presented to explain how the ketogenic diet works physiologically in PWE, and these are covered in this review. The ketogenic diet is very effective at controlling epilepsy but is difficult to tolerate. Hence other diets, especially the low glycaemic index diet, have been developed as an alternative (Qi & Tester, 2019). The authors proposed that another option for the dietary management of seizures is to consume a very slowly digestible glucose source, which minimizes the impact on insulin response, in conjunction with a source of ketones (preferably those generated from lipid metabolism) to optimize energy for the brain and body.

Physical exercise in PWEs

Determining whether subjects with epilepsy can be involved in specific physical exercises or specific sports requires a careful clinical assessment of the individual risk-benefit ratio, particularly with respect to the risk of a seizure occurring during the activity and related implications. Factors to be considered include not only the type of sport and the probability of a seizure occurring, but also individual characteristics, such as the type and severity of the seizures, the consistency of any prodromal manifestations, the history concerning any seizure-precipitating factors, the likelihood of adequate supervision by family members or other personnel, and the willingness of the informed PWE (or parents) to take a reasonable level of risk (Capovilla et al., 2016). A careful medical history is essential to ascertain not only the frequency and characteristics of the seizures, but also any previous seizure-related accidents or injuries, duration of periods of seizure freedom, and degree of adherence to treatment (Pimentel et al., 2015). Therefore, choosing a specific physical exercise/sport for a person with epilepsy requires consideration of personal attitudes and preferences, health status, as well as medical advice. To this point, recommendations for the issuance of certificates of fitness for sports activities are needed. In clinical studies, exercise has been reported to be associated with reduced epileptic form discharges on electroencephalography (EEG) and increased seizure threshold (Nakken, A. Løyning, T. Løyning, Gløersen, & Larsson, 1997), and seizures are unlikely to occur during incremental physical effort to exhaustion (de Lima et al., 2011). These findings are strengthened by studies in animal models of seizures and epilepsy, in which aerobic exercise training was found to retard the epileptogenic process to reduce seizure frequency (Vannucci Campos et al., 2017), and to promote favourable plastic changes in the hippocampus (Schipper et al., 2016). These benefits can be particularly prominent for children with epilepsy, and the involvement of these children in sports activities at school should be encouraged. Social exclusion is highly prevalent in the teen years, and teens with epilepsy are generally less physically active than their healthy siblings (Wong & Wirrell, 2006).

Furthermore, regular exercise can improve cognitive function at all ages (American College of Sports Medicine, 2009), and enforcing a sedentary lifestyle can have deleterious effects and impact on psychosocial development, independence, and mental health. These observations led to the general recommendation that PWEs should engage in physical exercise programmes or sport activities that do not impose a significant risk of injury to themselves or others. Assessing the risks involved in physical/sports activity participation is a responsibility to be shared among physicians, PWEs, and parents if the person with epilepsy is a child or adolescent. A few clinical cases of seizures apparently precipitated by physical exercise have been reported, in some instances in relation to stimulus-related or reflex epilepsy syndromes (Qi &Tester, 2019; Scheffer et al., 2018; Tsuji, 2017). However, a causative link between these factors and the occurrence of seizures in some of the reported instances is speculative, and, in general, sport activities are unlikely to provoke or facilitate the occurrence of seizures.

Some online sites counselling PWEs provide recommendations regarding different sport activities, and most are quite liberal in the sports recommended. Especially for PWEs with controlled epilepsy, however, conflicting opinions exist regarding more controversial physical activities, such as sky diving, scuba diving, water skiing, climbing, hand gliding, or boxing and other contact sports. Most assert that water sports should always be performed under a trained supervisor, with a lifejacket, and that swimming should be done in supervised pools (Monda et al., 2017b). Some consider that restrictions for persons with complex partial or tonic-clonic seizures are needed even when preceded by warnings for sports, such as skydiving and scuba diving. A more radical position is the one not recommending it in general for PWE because they are life-threatening in case of the occurrence of a seizure (Monteiro, Aroca, Margarit, & Herán, 2019). While some do not limit participation, others do not recommend or counsel caution for the practice of combat sports like boxing or martial arts that may involve blows to the head.

Nevertheless, as seen in the literature from studies with boxers and other sports that might involve concussions, most of these are mild and do not preclude the development of epilepsy nor do they aggravate pre-existing epilepsy. Taking into account the articles reviewed, there seems to be currently a consensus that sports and physical activity, excluding scuba diving, skydiving, and solo hand gliding, should be encouraged for all PWEs with controlled epilepsy (seizure-free for more than one year). For higher-risk sports like climbing, cycling, horseback riding, water sports and swimming, snorkelling, among others, PWEs should practice them with a friend/ relative, or under the close surveillance of someone who knows that the person has epilepsy and how to deal with the occurrence of a seizure.

For those PWEs not well-controlled, limitations should be applied according to the seizure type and the particular sport or physical activity to be performed, always after discussing the risks, benefits and sports possibilities, and the need for suitable protective equipment with the assistant physician and with the sports professional. The practice of sports is still an individual choice and decision because no guidelines are available according to each particular frequency or type of seizures and the intake of antiepileptic drugs (AEDs). However, those that continue having seizures only at night, or always preceded by an aura enabling the halting of activity should have fewer limitations than those with myoclonic, atonic, absence, complex partial, or tonic-clonic seizures. Rice and the Council of Sports Medicine and Fitness (Fishman et al., 2017) elaborated guidance for clinicians, and they do not recommend special precautions for those with controlled epilepsy. For those with uncontrolled seizures, an individual assessment for collision, contact or limited-contact sports, and avoidance of archery, swimming, weightlifting, and powerlifting (Washington et al., 2001).

Ketogenic Diet and epilepsy

The ketogenic diet (KD) is a nutritional approach consisting of high-fat and adequate protein content but insufficient levels of carbohydrates for metabolic needs <20 g d-1or 5% of total daily energy intake (Paoli, Bianco, & Grimaldi, 2015; Phinney, Bistrian, Evans, Gervino, & Blackburn, 1983), thus forcing the body primarily to use fat as a fuel source. The original KD was proposed as a 4:1 lipid:non-lipid ratio, with 80% of daily energy intake from fat, 15% protein, and 5% carbohydrate. Many modifications have subsequently been introduced to the original KD, for example, lowering the lipid:non-lipid ratio or no restrictions in daily energy (in kilojoules) intake with protein and fat. The primary knowledge on the metabolic aspects of KD comes from studies conducted at the end of the 1960s (Owen et al., 1967, 1969), which determined that fasting (i.e., ingesting no or minimal amounts of food and caloric beverages for periods that typically range from 12 h to 3 wk) induces a particular metabolic state called "ketosis" (Paoli, Bosco, Camporesi, & Mangar, 2015).

Ketosis, the metabolic response to an energy crisis, is a mechanism to sustain life by altering oxidative fuel selection. Often overlooked for its metabolic potential, ketosis is poorly understood outside of starvation or diabetic crisis. Ketone body metabolism is a survival trait conserved in higher organisms to prolong life during an energy deficit or metabolic crisis. The advantages of ketone body metabolism during starvation are clear: providing an oxidizable carbon source to conserve precious glucose/gluconeogenic reserves while simultaneously satisfying the specific fuel demands of the brain. Ketone bodies, when present, act not only as respiratory fuels to power oxidative phosphorylation but as signals regulating the preferential oxidation and mobilization of fuel substrates.

In the early 20th century, French and American physicians, including Guelpa, Marie, Conklin, and Geyelin, started research on fasting and starvation as a treatment for epilepsy. It was shown that fasting is more effective in treating children than adolescents and that its efficacy decreases with increasing age. Following that, researchers explained dehydration, acidosis, and ketosis as possible mechanisms by which fasting helps in treating epilepsy (Wigglesworth, 1924). Other authors proposed that the diet that produces ketosis could also be used in the treatment of epilepsy (Sadeghifar & Penry, 2019). It was termed the "Ketogenic Diet", which was rich in fat and deficient in carbohydrates. KD was found to be beneficial over starvation in providing similar efficacy but could be used for prolonged maintenance.

Later, in 1946, diphenylhydantoin was discovered, and the focus of research shifted to the development of other AED, which were convenient to administer. Due to seizures which remained uncontrolled despite several trials of AEDs, KD regained its popularity (Bashinski, 1946). In 1972, Dr Robert C. Atkins promoted the "Atkins Diet", which consisted of high fat and low carbohydrate and produces ketosis (Dr. Atkins' diet revolution, 1973). After that, "Modified Atkins Diet" was developed in 2003 (Miller et al., 2003). These diets were more palatable and tolerable than previous ones. Subsequently, low glycaemic index treatment diet was proposed in 2005, based on the hypothesis that stable blood glucose at a lower level would result in modulation of insulin release and other metabolic effects, thus improving the incidence of seizure (Pfeifer & Thiele, 2005).

Discussion

In general, several studies reported that physical activity has a positive influence on seizure frequency and severity (Vancampfort & Ward, 2019; Vancampfort, Ward, & Stubbs, 2019). As a result, attitudes regarding sports and epilepsy have changed considerably in recent decades, and presently, the risk of convulsive seizures during sports practice is minimal in cases of well-managed epilepsy (van Gorp et al., 2019). Evaluating the control of convulsive disease is, therefore, a key point in allowing sports for children and adolescents. In cases of well-controlled epilepsy, both team sports and contact or collision sports are allowed, with appropriate equipment, and the training of both parents and coaches. These data are not applicable in subjects with epileptic encephalopathies or cases of not-controlled seizures or pharmaco-resistant epilepsy (Janmohamed, Brodie, & Kwan, 2019).

Patients with epilepsy who wish to participate in sports represent a challenging population to counsel and manage because their condition puts them at risk for possibly life-threatening events; however, most of these risks are manageable. High-risk activities for this population include water sports and any water-related activity (Pimentel et al., 2015). The athlete with epilepsy who participates in such activities should have constant supervision by a responsible adult or a "buddy" who can provide immediate assistance and maximally reduce the risk of drowning, which is never negligible (Messina et al., 2015). The athlete's frequency of seizures is also a factor in determining whether his or her participation in high-risk activities is advisable. Patients with frequent seizures should be guided toward activities in which loss of consciousness or bodily control is not life-threatening. Athletes with known seizure disorders have not been reported to exhibit a higher incidence of seizures in comparison with their baseline frequencies when they play contact sports (Shehzad, Iqbal, Shehzad, & Lee, 2012; Vancini, Andrade, Vancini-Campanharo, & de Lira, 2017).

Collision sports associated with a higher number of and more forceful impacts resulting in a higher rate of concussions may place the brain at risk of seizures secondary to the increase in excitatory neurotransmitters during the acute phase of the injury, as has been described in animal models of brain injury (Viggiano et al., 2016). Clinical experience to date demonstrates that low-impact injuries typically seen in most competitive sports do not put athletes with epilepsy at increased risk for seizures (Fisher et al., 2014; Monda et al., 2017a; Pimentel, Tojal, & Morgado, 2015; Scheffer et al., 2018).

Regarding the effects of AEDs in sporting practise by children affected by epilepsy, in general, AEDs can slow mental processing, trigger physiologic changes, and cause imbalance and fatigue with reduced endurance, all of which negatively affect competitive performance (Chieffi et al., 2017). Consequently, athletes who notice these drops in performance may limit their compliance with these medications (Moscatelli et al., 2016; Operto et al., 2019). Appetite can also be affected by the use of medications, with anorexia causing a diminution of adequate nutrition that affects strength and endurance and increases the risk of seizures (Fishman et al., 2017; Owen, Felig, Morgan, Wahren, & Cahill, 1969; Paoli et al., 2015; Phinney et al., 1983; Washington et al., 2001).

People with chronic diseases, including epilepsy, should be encouraged to exercise, as should the general population. The mental and physical advantages of regular exercise are regarded as highly beneficial to a group that is usually sedentary, overweight, and with higher rates of depression.

Sports medicine professionals should have an understanding of epilepsy syndromes, types of seizures, medications, what to do when a seizure occurs during sports practice, the effect of physical exercise on seizures, and when restrictions are applied to the practice of sports (Pimentel et al., 2015). General physicians, neurologists and paediatricians should support the practice of regular physical exercise and inform patients and caregivers about the benefits associated with physical activity and the necessary precautions, such as protective gear.

Participation in organized sports provides many physical and psychological benefits for patients with epilepsy and can be safely incorporated into their lives (Iannone et al., 2019; Operto et al., 2019). By providing appropriate education and encouragement, a neurologist can ensure that patients are properly equipped to make the right choices and manage any complications that occur while they are participating in activities (Operto et al., 2019; Operto et al., 2020).

In conclusion, physical exercise and KD has a positive effect on epilepsy and is associated with reduced epileptic form discharges and increased seizure threshold, and seizures are unlikely to occur during incremental physical effort to exhaustion (Rauchenzauner et al., 2017). These findings are strengthened by studies in animal models of seizures and epilepsy, in which aerobic exercise training was found to retard the epileptogenic process, to reduce seizure frequency, and to promote favourable plastic changes in the hippocampus (Olivares et al., 2011).

Acknowledgements
There are no acknowledgements.

Conflict of Interest
The authors declare the absence of conflict of interest.

Received: 14 March 2020 | **Accepted:** 25 May 2020 | **Published:** 01 February 2021

References

American College of Sports Medicine (2009). Progression models in resistance training for healthy adults. *Medicine and Science in Sports and Exercise*, *41*(3), 687-708. https://doi.org/10.1249/MSS.0b013e3181915670

Bashinski, B. (1946). Treatment of epilepsy in children with sodium dilantin. *Journal of the Medical Association of Georgia*, *35*, 228.

Capovilla, G., Kaufman, K. R., Perucca, E., Moshé, S. L., & Arida, R. M. (2016). Epilepsy, seizures, physical exercise, and sports: A report from the ILAE Task Force on Sports and Epilepsy. *Epilepsia*, *57*(1), 6-12. https://doi.org/10.1111/epi.13261

Chieffi, S., Messina, G., Villano, I., Messina, A., Valenzano, A., Moscatelli, F., … Monda, M. (2017). Neuroprotective effects of physical activity: Evidence from human and animal studies. *Frontiers in Neurology*, *8*(188), 1-7. https://doi.org/10.3389/fneur.2017.00188

de Lima, C., Vancini, R. L., Arida, R. M., Guilhoto, L. M. F. F., de Mello, M. T., Barreto, A. T., … Tufik, S. (2011). Physiological and electroencephalographic responses to acute exhaustive physical exercise in people with juvenile myoclonic epilepsy. *Epilepsy and Behavior*, *22*(4), 718-722. https://doi.org/10.1016/j.yebeh.2011.08.033

Dr. Atkins' diet revolution (1973). *Medical Letter on Drugs and Therapeutics*.

Fisher, R. S., Acevedo, C., Arzimanoglou, A., Bogacz, A., Cross, J. H., Elger, C. E., … Wiebe, S. (2014). ILAE Official Report: A practical clinical definition of epilepsy. *Epilepsia*, 55(4), 475-482. https://doi.org/10.1111/epi.12550

Fishman, M., Taranto, E., Perlman, M., Quinlan, K., Benjamin, H. J., & Ross, L. F. (2017). Attitudes and Counseling Practices of Pediatricians Regarding Youth Sports Participation and Concussion Risks. *Journal of Pediatrics*, *184*, 19-25. https://doi.org/10.1016/j.jpeds.2017.01.048

Iannone, L. F., Preda, A., Blottière, H. M., Clarke, G., Albani, D., Belcastro, V., … Striano, P. (2019). Microbiota-gut brain axis involvement in neuropsychiatric disorders. *Expert Review of Neurotherapeutics*, *19*(10), 1037–1050. https://doi.org/10.1080/14737175.2019.1638763

Janmohamed, M., Brodie, M. J., & Kwan, P. (2019). Pharmacoresistance - Epidemiology, mechanisms, and impact on epilepsy treatment. *Neuropharmacology*, *168*, 107790. https://doi.org/10.1016/j.neuropharm.2019.107790

Kaufman, K. R., & Kaufman, N. D. (2013). Stand up for epilepsy san diego photo-shoot: A personal odyssey. *Epileptic Disorders*, *15*(2), 211-5. https://doi.org/10.1684/epd.2013.0585

Messina, G., Zannella, C., Monda, V., Dato, A., Liccardo, D., S, D. B., … Monda, M. (2015). The Beneficial Effects of Coffee in Human Nutrition, *7*(4), 1-5.

Miller, B. V., Bertino, J. S., Reed, R. G., Burrington, C. M., Davidson, L. K., Green, A., … Nafziger, A. N. (2003). An Evaluation of the Atkins' Diet. *Metabolic Syndrome and Related Disorders*, 1(4). https://doi.org/10.1089/1540419031361426

Monda, V., Ruberto, M., Villano, I., Valenzano, A., Ricciardi, A., Gallai, B., … Salerno, M. (2017a). A minireview about sporting practice in epileptic children. *Acta Medica Mediterranea*, *33*, 1279-1287. https://doi.org/10.19193/0393-6384_2017_2s_197

Monda, V., Valenzano, A., Moscatelli, F., Salerno, M., Sessa, F., Triggiani, A. I., … Messina, A. (2017b). Primary Motor Cortex Excitability in Karate Athletes: A Transcranial Magnetic Stimulation Study. *Frontiers in Physiology*, *8*, 695. https://doi.org/10.3389/fphys.2017.00695

Monteiro, G. C., Aroca, I. L. Z., Margarit, B. P., & Herán, I. S. (2019). Epilepsy. *Medicine (Spain)*, *12*(72), 4222-4231. https://doi.org/10.1016/j.med.2019.02.003

Moscatelli, F., Messina, G., Valenzano, A., Monda, V., Viggiano, A., Messina, A., … Cibelli, G. (2016). Functional Assessment of Corticospinal System Excitability in Karate Athletes. *PloS One*, *11*(5), e0155998. https://doi.org/10.1371/journal.pone.0155998

Nakken, K. O., Løyning, A., Løyning, T., Gløersen, G., & Larsson, P. G. (1997). Does physical exercise influence the occurrence of epileptiform EEG discharges in children? *Epilepsia*, *38*(3), 279-284. https://doi.org/10.1111/j.1528-1157.1997.tb01118.x

Olivares, A., Olivares, G., Mula, F., Górriz, J. M., & Ramírez, J. (2011). Wagyromag: Wireless sensor network for monitoring and processing human body movement in healthcare applications. *Journal of Systems Architecture*, *57*(10), 905-915. https://doi.org/10.1016/j.sysarc.2011.04.001

Operto, F. F., Coppola, G., Mazza, R., Pastorino, G. M. G., Campanozzi, S., Margari, L., … Carotenuto, M. (2019). Psychogenic nonepileptic seizures

in pediatric population: A review. *Brain and Behavior*, *9*(12), e01406. https://doi.org/10.1002/brb3.1406
Operto, F. F., Pastorino, G. M. G., Mazza, R., Carotenuto, M., Roccella, M., Marotta, R., … Verrotti, A. (2020). Effects on executive functions of antiepileptic monotherapy in pediatric age. *Epilepsy & Behavior*, *102*, 106648. https://doi.org/10.1016/j.yebeh.2019.106648
Owen, O. E., Morgan, A. P., Kemp, H. G., Sullivan, J. M., Herrera, M. G., & Cahill, G. F. (1967). Brain metabolism during fasting. *The Journal of Clinical Investigation*, *46*(10), 1589-1595. https://doi.org/10.1172/JCI105650
Owen, O. E., Felig, P., Morgan, A. P., Wahren, J., & Cahill, G. F. (1969). Liver and kidney metabolism during prolonged starvation. *The Journal of Clinical Investigation*, *48*(3), 574-583. https://doi.org/10.1172/JCI106016
Paoli, A., Bianco, A., & Grimaldi, K. A. (2015). The Ketogenic Diet and Sport: A Possible Marriage? *Exercise and Sport Sciences Reviews*, *43*(3), 153-162 https://doi.org/10.1249/JES.0000000000000050
Paoli, A., Bosco, G., Camporesi, E. M., & Mangar, D. (2015). Ketosis, ketogenic diet and food intake control: A complex relationship. *Frontiers in Psychology*, *6,* 27. https://doi.org/10.3389/fpsyg.2015.00027
Pfeifer, H. H., & Thiele, E. A. (2005). Low-glycemic-index treatment: A liberalized ketogenic diet for treatment of intractable epilepsy. *Neurology*, *65*(11), 1810-1812. https://doi.org/10.1212/01.wnl.0000187071.24292.9e
Phinney, S. D., Bistrian, B. R., Evans, W. J., Gervino, E., & Blackburn, G. L. (1983). The human metabolic response to chronic ketosis without caloric restriction: Preservation of submaximal exercise capability with reduced carbohydrate oxidation. *Metabolism*, *32*(8), 769-776, https://doi.org/10.1016/0026-0495(83)90106-3
Pimentel, J., Tojal, R., & Morgado, J. (2015). Epilepsy and physical exercise. *Seizure*, *25*, 87-94. https://doi.org/10.1016/j.seizure.2014.09.015
Qi, X., & Tester, R. F. (2019). The 'epileptic diet'- ketogenic and/or slow release of glucose intervention: A review. *Clinical Nutrition*, *39*(5), 1324-1330. https://doi.org/10.1016/j.clnu.2019.05.026
Rauchenzauner, M., Hagn, C., Walch, R., Baumann, M., Haberlandt, E., Frühwirth, M., & Rostasy, K. (2017). Quality of Life and Fitness in Children and Adolescents with Epilepsy (EpiFit). *Neuropediatrics*, *48*(03), 161-165. https://doi.org/10.1055/s-0037-1599236
Sadeghifar, F., & Penry, V. B. (2019). Mechanisms and Uses of Dietary Therapy as a Treatment for Epilepsy: A Review. *Global Advances in Health and Medicine*, *8*, 1-4. https://doi.org/10.1177/2164956119874784
Scheffer, I. E., Berkovic, S., Capovilla, G., Connolly, M. B., French, J., Guilhoto, L., … Zuberi, S. M. (2018). ILAE classification of the epilepsies: position paper of the ILAE Commission for Classification and Terminology. *Zeitschrift Fur Epileptologie*, *31*, 296–306. https://doi.org/10.1007/s10309-018-0218-6
Schipper, S., Aalbers, M. W., Rijkers, K., Lagiere, M., Bogaarts, J. G., Blokland, A., … Vles, J. S. H. (2016). Accelerated cognitive decline in a rodent model for temporal lobe epilepsy. *Epilepsy and Behavior*, *65*, 33-41. https://doi.org/10.1016/j.yebeh.2016.08.025
Shehzad, A., Iqbal, W., Shehzad, O., & Lee, Y. S. (2012). Adiponectin: regulation of its production and its role in human diseases. *Hormones (Athens, Greece)*, *11*(1), 8–20. https://doi.org/10.4161/epi.19547
Tsuji, S. (2017). Participation of people with epilepsy in sports. *Brain and Nerve*, *69*(2), 151-158. https://doi.org/10.11477/mf.1416200655
van Gorp, M., E. Roebroeck, M., van Eck, M., M. Voorman, J., Twisk, J. W. R., J. Dallmeijer, A., & van Wely, L. (2019). Childhood factors predict participation of young adults with cerebral palsy in domestic life and interpersonal relationships: a prospective cohort study. *Disability and Rehabilitation*, Ahead-of-Print, 1-10. https://doi.org/10.1080/09638288.2019.1585971
Vancampfort, D., & Ward, P. B. (2019). Physical activity correlates across the lifespan in people with epilepsy: a systematic review. *Disability and Rehabilitation*, 1–8. https://doi.org/10.1080/09638288.2019.1665113
Vancampfort, D., Ward, P. B., & Stubbs, B. (2019). Physical activity and sedentary levels among people living with epilepsy: A systematic review and meta-analysis. *Epilepsy & Behavior*, *99*, 106390. https://doi.org/10.1016/j.yebeh.2019.05.052
Vancini, R. L., Andrade, M. dos S., Vancini-Campanharo, C. R., & de Lira, C. A. B. (2017). Exercise and sport do not trigger seizures in children and adolescents with epilepsy in school settings. *Arquivos de Neuro-Psiquiatria*, 75(10), 761. https://doi.org/10.1590/0004-282x20170111
Vannucci Campos, D., Lopim, G. M., da Silva, D. A., de Almeida, A. A., Amado, D., & Arida, R. M. (2017). Epilepsy and exercise: An experimental study in female rats. *Physiology and Behavior*, *171*, 120-126. https://doi.org/10.1016/j.physbeh.2016.12.040
Viggiano, E., Monda, V., Messina, A., Moscatelli, F., Valenzano, A., Tafuri, D., … Monda, M. (2016). Cortical spreading depression produces a neuroprotective effect activating mitochondrial uncoupling protein-5. *Neuropsychiatric Disease and Treatment*, *12*, 1705–1710. https://doi.org/10.2147/NDT.S107074
Washington, R. L., Bernhardt, D. T., Gomez, J., Johnson, M. D., Martin, T. J., Rowland, T. W., … Newland, H. (2001). Medical conditions affecting sports participation. *Pediatrics*, *107*(5), 1205-1209. https://doi.org/10.1542/peds.107.5.1205
Wigglesworth, V. B. (1924). Studies on Ketosis: I. The Relation between Alkalosis and Ketosis. *Biochemical Journal, 18*(6), 1203–1216. https://doi.org/10.1042/bj0181203
Wong, J., & Wirrell, E. (2006). Physical activity in children/teens with epilepsy compared with that in their siblings without epilepsy. *Epilepsia*, *47*(3), 631-639. https://doi.org/10.1111/j.1528-1167.2006.00478.x

DOI 10.26773/smj.210214

SHORT REPORT

Cartography in Sports and Sports in Cartography

Goran Barovic[1], Dusko Vujacic[1] and Velibor Spalevic[1]

[1]University of Montenegro, Faculty of Philosophy, Niksic, Montenegro

Abstract

This paper presents the author's aspiration to determine a connection between cartography and sports. Cartography, created even before the advent of writing, allowed man to portray a part of the space in which he lived. This way of connecting cartography with other scientific disciplines has been done on several occasions. Its connection with, for example, ecology, climatology, hydrography has been explained, so this will be another in a series of works from a wide range of scientific fields with which a connection is made. The aim of this paper is to determine possible connections between cartography and sport in all its forms of appearance. Sports, once merely a set of physical activities and skills, is now a field in which science is making spectacular discoveries related to numerous human works. Interconnected in several ways, they complement each other and help each other in accomplishing certain tasks. Cartography seeks topics and ways of presenting interesting and diverse content related to sports sciences and sports activities, while sport in cartography finds help in communicating the results of scientific research, and also uses it as an aid and service in numerous sports events, thus facilitating work processes. The paper will also explain the use of the cartographic method, which is the basic method of work in cartography with implementation procedures, as well as the scientific meaning that is manifested through the definition of three categories: spatial, temporal and essential definition. By analyzing all of the above, it can be concluded that the connection between cartography and sports has been realized for mutual benefit. Cartography expands its possibilities of work and presentation on given topics, while sport in all its areas gets a chance to express everything that is important to it and to make it very clear and easy to understand.

Keywords: *cartography, sport map, cartographic method, cartographic sign*

Introduction

The universality of the cartographic display is reflected in its connection with many areas of work. The language of expression is universal and understandable, provided that the rules of the cartographic presentation have been followed. This universality is reflected in the possibility that, using the expressive means, the elements of an area can be shown in a manner that will be understood by the users, regardless of the degree of knowledge of the displayed space. One particular advantage is reflected in the ability of a map to eliminate the language barrier, which significantly increases the potential number of users. The use of cartographic displays that relate to activities in sports is very common. They can be conditionally divided into two groups: the first is the use of maps for the communication and presentation of scientific research related to sports science and the second is the mapping of space in terms of displaying infrastructure and events of a sporting character. (e.g., Olympic Games, World Championships, regional competitions, map of the Olympic Village, the layout of facilities where competitions at the World Championships are held, etc.). In both cases, the connection between cartography and sport comes to a clear expression, because cartography in the presentation of scientific or event content has the opportunity to be shown through numerous possibilities from a wide range of methods and expressive means, while in contrast sports science

Correspondence:

G. Barovic
University of Montenegro, Faculty of Philosophy, Danila Bojovica bb, 81400 Niksic, Montenegro
E-mail: goranbarovic@yahoo.com

and events receive an excellent way of communicating scientific results and providing information to participants of events and users of sports infrastructure that were mapped (Buric & Barovic, 2005).

The aim of this paper is to determine possible connections between cartography and sport in all its forms of appearance.

Methods

Which of the cartographic mapping methods we can use depends on several factors that determine their use. Mapping methods can be seen through two levels of analysis. One is the use of a cartographic method as a basic scientific method through which we map out the analysed themes; another is the choice of an appropriate mapping method in relation to the task set, which, in relation to the essence of the appearance of the phenomenon, should be chosen by the appropriate method by which its qualitative, quantitative, or universal characteristics should be shown (Ljesevic, 1981).

When it comes to the use of cartographic methods, as a basic scientific method, cartography takes place through two procedures that need to be carried out in order to fulfil the task set. The first is mapping, which represents the separation of the necessary elements from the space that reflect the character of the phenomenon that is being mapped. In this process, it is necessary to collect as much data as possible on the mapping object in order to form a database that should be as large as possible. The following procedure is the process of obtaining mapped space data, which is realized by looking at the mapped content, which enables obtaining a larger amount of information than that which is entered by primary mapping. By using this method, it is possible to define the following scientific categories. Spatial relationships can be defined by positioning the results of the survey in relation to the accepted spatial system. This can be done in two ways in mapping sports-related topics. One is the input of the survey results into the territory where it was done, and the other is the positioning of objects in the space, for example, the display of the sports complexes, the Olympic villages, and similar.

Time defining can also be done in many ways, such as when communicating scientific research through the presentation of the movement of the investigated results during the defined period and presentation of the results at the moment of the research. When displaying the schedule of infrastructure related to sports events, this can be done, for example, with the development of sports complexes in a defined time interval or positioning at the moment of observation. The essential definition is the presentation of qualitative and quantitative characteristics of the mapped space. This way of defining enables determining cause-effect connections, analysis, synthesis, conclusions, as well as many other ways of looking at the mapped space.

When choosing a mapping method, it is necessary to take into account the essence of the displayed phenomenon because, in relation to this feature, the methods are divided into qualitative ones, which include the method of qualitative targeting and areas, and the quantitative targeting, which include the methods of isolines, points, and cartograms and universal ones like the line of movement, characters, cardiograms, and vectors. Among the methods listed, it is not possible to make a strict boundary because some methods, depending on the choice of the cartographic expression agent, can also have qualitative and quantitative properties.

Results

Establishing a closer link between cartography and sports science can contribute advancements for both scientific disciplines. Through the examination of the results of scientific research in sport, cartography will find new ways of displaying and perfecting its expressive means by enriching their number, but also their forms, in order to facilitate the use of the map to the potential user and the optimal understanding of the presented results. The greatly improved quality of new maps makes it possible to perceive more value and more information than in the data used for their creation. New maps can also be the subject of new research as well as determining the causal links between mapped content that again give new results. Sports science, through a cartographic presentation of its results, obtains a very clear, easily legible, and recognizable way of communicating its research results. As already mentioned, the language of cartography is universal, and there are none of the barriers that some other ways of presenting research procedures have.

There are more examples in which the connection between cartography and sports has been established, and in this review, we will show this through three examples: use of maps in preserving scientific-research works, maps showing a skiing complex, and a map used for the competition in orientation.

Numerous scientific papers testify about the connection between cartography and sports science. One of these studies treated body mass index (BMI), weight, overweight and obesity from 1975 to 2016 through a combined analysis of 2416 studies based on the population of 128.9 million samples (Figure 1). The paper cartographically presents BMI, the prevalence of obesity and weight loss for girls and boys through the presentation of a political map of the world in which the method of qualitative reorientation was used, and colour was used as the dominant cartographic expression.

With the precise legend, the values of the investigated indicators are defined through which the value of the indicators is indicated by the different colour intensities (the lighter tones are lower and darker tones are higher). Also, as a special addition, the results of the survey for the countries are shown, which are not visible on the map of the world because of its small scale, for the reason of not compromising the legibility threshold. Although this map has many shortcomings in the sense of omitting a number of mandatory elements, in this case, as a thematic map, it has fulfilled the function and provided the information presented by the work.

Frequently used maps that display sports complexes, and are operated according to the universal rules applicable to all centres of this type, represent ski resorts. The map that is being processed is a map showing the Livigno Ski Resort, at the border of Italy and Switzerland (Figure 2). To display the contents, methods of vector and signs were used, as well as expressive cartographic means: colour, simple geometric signs, symbolic signs, numerical scalars, and vectors. The lines show the ski runs by the difficulties (black, red and blue) with the symbolic signs of the cable car (gondolas, two-seaters, four-seater,

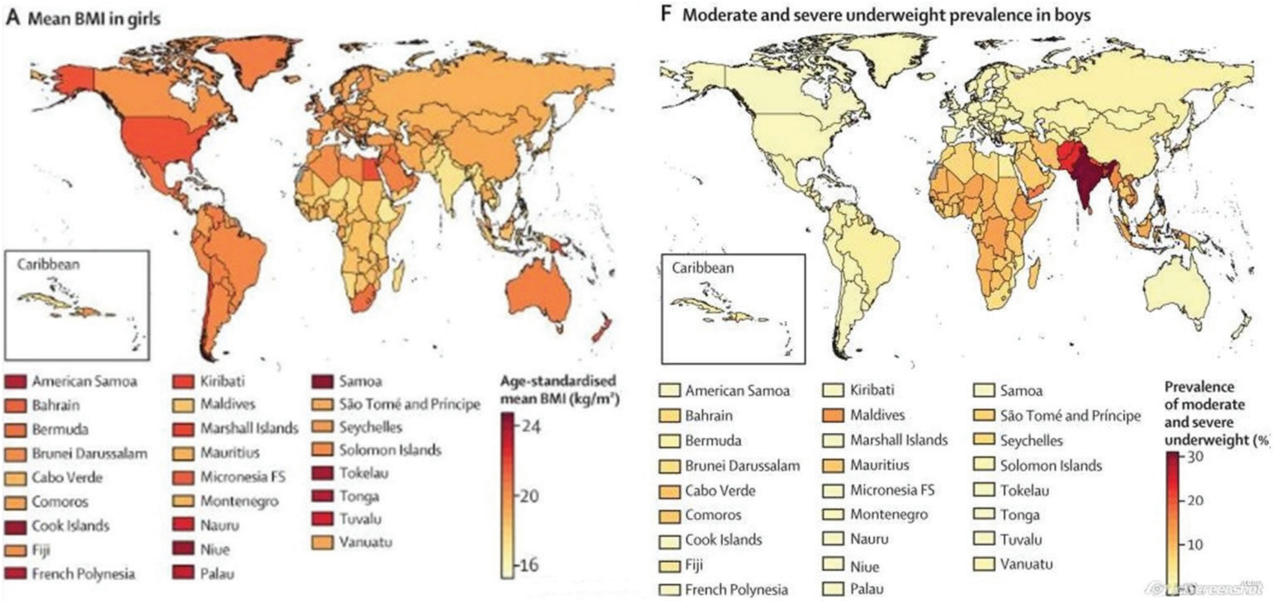


FIGURE 1. Body mass index (BMI) mapping for girls and nutrition of boys (NCD Risk Factor Collaboration, 2017)

anchors), snowboarding and children's parks, wi-fi locations, parking lots, information points, altitudes of characteristic points and site names. Relief shapes are displayed with the use of colour and dashes that symbolize the forest cover and shadows to highlight its plasticity. The accompanying legend contains all the topographic characters used to display the content so that the user gets complete information about the content presented. This map also has a number of shortcomings from the group of map elements, but since it is a specialized thematic map, they can be ignored.

FIGURE 2. Map of Livigno

Maps used for orientation competitions also belong to the group of thematic maps. These are specialized maps that have the purpose of providing competitors with information that will help them master the set itinerary. Classical topographic maps can also be used for making maps used for orientation competitions, but specialized thematic maps are also available. Depending on the surface of the terrain where the competition is held, the proportions belong to the group of large scale maps. The map that was the subject of the analysis was made for the orientation competition that was held within the 11th Cartography and Geoinformation Meeting in Buzet in 2015 (Figure 3). The method of qualitative targeting, vectors and points was used for the development of the map of the old town of Buzet. Colour, simple geometric signs and numerical signs were used as a medium of expression. As a special addition to the map, in addition to the legend, the image symbols of the characteristic objects are given, which are at the same time represented the control points that the competitors should visit in the order.

FIGURE 3. Sprint orienteering event

Discussion

The product of cartographic work is a map, as a presentation of the characteristics of a space that for some reason are separated from a particular unit or are presented as a separate thematic area to provide information about it. The language of the map is universal and has no boundaries. The means of expression used are defined by international rules that allow the map user to navigate by reading the presented content, regardless of possible language barriers that may arise if the map issuer is from a country whose language we do not know. There is practically no scientific area in which content cannot be expressed by cartographic presentation.

In conclusion, there is a strong connection between cartography and sports on several levels. Both need to cooperate and explore numerous opportunities. It is practically inconceivable to hold a number of sports events without a cartographic presentation of the facilities, but also the space in which they are held. Certainly, such displays facilitate the movement of the participants of the events, give guidelines for easier orientation of the contestants, and similar. A special connection is made when communicating the scientific results that have been achieved during the research procedures of numerous areas of sports sciences.

Acknowledgements
There are no acknowledgements.

Conflict of Interest
The authors declare the absence of conflict of interest.

Received: 20 August 2020 | **Accepted:** 07 October 2020 | **Published:** 01 February 2021

References

Buric, M., & Barovic G. (2005). *Fundamentals of cartography*. University of Montenegro, Faculty of Philosophy: Niksic.

Ljesevic, M. (1981). Cartographic method in the system of scientific methods and its place in geography. Globus, no. 13. Belgrade. *Serbian Geographical Society*, 52 - 60.

NCD Risk Factor Collaboration (NCD-RisC) (2017). Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128·9 million children, adolescents, and adults. *Lancet (London, England)*, *390*(10113), 2627–2642. https://doi.org/10.1016/S0140-6736(17)32129-3

DOI 10.26773/smj.210210

SHORT REPORT

Leather Balls Influence Three-Point Scores by University Basketball Players more than Synthetic or Rubber Balls Do

Gopal Kumar[1] and Rohit Kumar Thapa[2]

[1]Lakshmibai National Institute of Physical Education, Department of Exercise Physiology, Gwalior, India, [2]Lakshmibai National Institute of Physical Education, Department of Sports Biomechanics, Gwalior, India

Abstract

This study aimed to compare the influence of ball type on three-point shooting in university basketball players. Forty university basketball players were selected for the study (Mean±SD; for male subjects: age 22±1.3 years; height 1.68±0.85 m; body mass 66.4±7.1 kg; fat 10.3±2.28% and for female subjects: age 20±1.6 years; height 1.36±0.88 m; body mass 62.4±6.9 kg; fat 11.6±3.48%). A 2×3 repeated measures ANOVA revealed a significant main effect in score with ball type ($F_{(2,76)}$=48.37, $p<0.001$, partial eta squared=0.56). Further analysis with post hoc testing revealed significant differences between synthetic and leather ball ($p<0.001$, d=1.27), and rubber and leather balls ($p<0.001$, d=1.48). No significant interaction effect of gender and ball type was found ($p=0.706$, partial eta squared=0.009). An independent t-test found no significant differences in three-point scores between male and female players in any ball type.

Keywords: *ball type, scoring, unopposed throw, ball quality, male versus female*

Introduction

Basketball is a popular sport that is played with a ball. Even though many sports use balls, each sport is associated with a specific type of ball that is distinctly different from others. The performance of players is directly influenced by the properties or characteristics of the ball (Connor, Sinclair, Leicht, & Doma, 2019; Cooke & Davey, 2005; Santos et al., 2020). Teams accumulate points in the sport of basketball by putting the ball through the hoop. Therefore, shooting is a very important skill and directly influences the team's success (Button, Macleod, Sanders, & Coleman, 2003; Knudson, 1993; Malone, Gervais, & Steadward, 2002).

A survey paper by Okazaki, Rodacki, and Satern (2015) studied various factors that affect shooting in basketball, including (a) ball trajectory, (b) segmental movement organization, and (c) variables that influence shooting performance (basket height, ball size, etc.), but the researcher found negligible data related to the effect of various ball types on shooting.

Recent studies conducted with different types of balls suggest that changing the ball type influences the youth footballers' performance during small-sided games (Santos et al., 2020), cricket batters' performance (Connor et al., 2019), and tennis players' performance and physiological responses (Cooke & Davey, 2005). Although no recent study has been conducted on the influence of the type of basketball used for shooting performance, an earlier study by Mathes and Flatten (1982) reported that synthetic basketballs do not have the same rebound characteristics as leather basketballs. The results also suggested that in play, the leather basketball would rebound further from backboards and could be dribbled with less effort than the synthetic basketballs (Mathes & Flatten, 1982).

Rubber basketballs are made with outer and core material as rubber but with a butyl bladder (http://cosco.in). Synthetic basketballs are also made with rubber outer material but have a leather feel with high grip pebbles and broad, deep grove patterns (http://cosco.in), whereas leather basketballs are made

Correspondence:

G. Kumar,
Lakshmibai National Institute of Physical Education, Department of Exercise Physiology, 474002, Gwalior, India.
+919589659793
Email: gopalk.kumar8@gmail.com

with outer material as leather reinforced with multi-filament nylon (http://cosco.in).

Thus, this study aimed at finding the influence of the type of material of ball in three-point shooting through different angles from the ring.

Method

Subjects

For this study, a total of 40 university basketball players were included with 20 male and 20 female players (Mean±SD; for male subjects: age 22±1.3 years; height 1.68±0.85 m; body mass 66.4±7.1 kg; fat % 10.3±2.28% and for female subjects: age 20±1.6 years; height 1.36±0.88 m; body mass 62.4±6.9 kg; fat % 11.6±3.48%). The subjects had a minimum playing experience of four or more years in the university. Subjects with recent records of lower limb or upper limb injury, neuromuscular disorder or back injury were excluded from the study. A written informed consent form was signed by the subjects after explanation of the procedure and possible risk involved in the study. The study was approved by the institutes' Departmental Research Committee with considerations regarding ethical issues reported in Helsinki Declaration.

Procedure

A week-long familiarization session was conducted with the three different ball types after regular training sessions. Anthropometric measurements were recorded a day before the assessments. Five different positions were marked on the court at three-point arc with angles: 0°, 45°, 90°, 45° and 0°. Each participant was allowed five attempts from each angle with each ball type. A total of 25 shots with each ball were given, and only successful attempts were recorded as having scored. Different positions of shooting are shown in Figure 1.

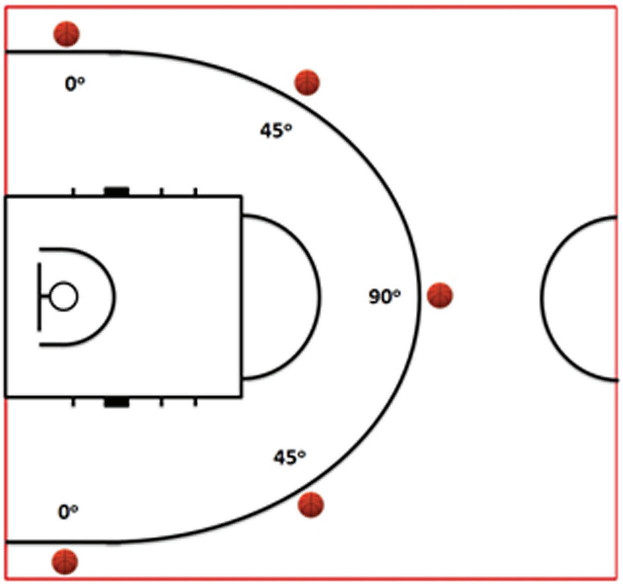


FIGURE 1. Angles of three-point shooting from the ring

Balls used in the procedure were of the Cosco brand, approved by the Basketball Federation of India (specifically with product names Cosco Dribble as the rubber ball, Cosco Hi-Grip as the synthetic ball and Cosco Championship as the leather ball). Different size balls were used for male and female subjects as used in the FIBA governed tournaments (Size 6 for females and Size 7 for males).

All the subjects were evaluated on the same day (09:00 to 16:00) by conducting three sessions with a gap of 2 hours between the sessions to avoid any carryover effect. At the beginning of every session, subjects first underwent a 10-minute warm-up to familiarize themselves with the ball, followed by the first trial which included 25 shots in total from five different angles with a particular ball type. After the completion of the first trial, a break of 10 minutes of active recovery was given, followed by the second trial. The total baskets made out of the 25 shots were taken as the score. The best score out of the two trials was considered to be the final score.

Statistical analysis

IBM SPSS (version 20.0.0) software was used for the analysis of the data. Data are presented as Mean±SD. Normality of the data was verified using a Shapiro-Wilk test. A 2×3 repeated measures ANOVA with gender (male and female) as between-subject factor and ball type (synthetic, rubber, and leather) as within-subject factor was used for analysis of the effect of ball type on three-point shooting. Post-hoc test with Bonferroni correction was used for further analysis of the data. Independent t-tests were used for comparison of male and female three-point scores with different ball type. Cohens' d and partial eta squared were calculated as effect sizes.

Results

A 2×3 repeated measures ANOVA revealed a significant main effect in score with ball type ($F_{(2,76)}=48.37$, $p<0.001$, partial eta squared=0.56). Further analysis with post hoc testing revealed significant differences between synthetic and leather ball ($p<0.001$, $d=1.27$), and rubber and leather ball ($p<0.001$, $d=1.48$). No significant interaction effect of gender and ball type was found ($p=0.706$, partial eta squared=0.009). Independent t-test found no significant differences in three-point scores between male and female players in any ball type. All the data are presented in Table 1.

Table 1. Mean and SD of scores using different ball type

Ball type	Gender	Scores (Mean±SD)	p-value and ES (d) male vs female	p-value and ES (partial eta squared) (main effect)	p-value and ES (partial eta squared) (gender×ball type)	p-value and effect Size (d) in comparison with leather ball
Synthetic	Male	10.65±2.7	0.112 (0.51)	<0.001* (0.56)	0.706 (0.009)	<0.001* (1.27)
	Female	11.85±2.3				
Rubber	Male	10.15±1.95	0.089 (0.55)			<0.001* (1.48)
	Female	11.4±2.54				
Leather	Male	14.05±2.8	0.423 (0.26)			-
	Female	14.7±2.25				

Legend: SD - standard deviation; ES - effect size; d - Cohens' d

Discussion

The main objective of this study was to compare the three-point scoring ability of university basketball players using different types of basketballs (viz. synthetic, rubber and leather balls). The result suggests an influence of ball type in scoring ability with more favourable scoring conditions with leather balls than rubber or synthetic balls.

A recent study conducted by Connor et al. (2019) on the effect of two different types of cricket balls utilized during a competition reported that pace bowlers were more successful in transferring their skill to the one type of ball (Duke™), while the spin bowlers were more successful with another type (Kookabura™). In the same vein, our findings also showed that the type of ball influenced the three-point shooting ability with more successful shots with a leather ball. Although the authors do not have sufficient evidence to support the statement, there may be a possibility of leather balls being more comfortable to hold during the throws than rubber or synthetic balls. The feeling of the leather grip may have also affected the throws.

In addition to this, a study by Julian & Price (2017) reported that the official game ball for the National Basketball Association (NBA) was changed from leather to synthetic in the 2006–2007 season. The NBA argued that a synthetic ball to be superior to the leather ball and suggested that it would improve performance. However, the league reverted to use leather ball after the National Basketball Association Players Association (NBAPA) filed an unfair practice labour grievance against the league. The NBAPA argued that it decreased performance, in contradiction to the suggestion by the NBA. This suggests that the use of leather balls was found to be suitable by the players, similar to what our finding suggests.

Previous studies have reported that materials used in manufacturing the balls influence the properties of the ball. Mathes and Flatten (1982) found that leather basketballs rebounded significantly higher than synthetic basketballs on different playing surfaces (polyurethane, asphalt, glass, concrete, hardwood). A study by Inaba et al. (2017) also found different coefficients of restitution, friction, and trajectories in table tennis ball post-collision for celluloid and plastic balls. These two studies show that material used in ball does affect the properties of the ball. Although the researchers did not study collisions, differences in the material of the ball must have influenced the three-point shooting scores.

Furthermore, there was no significant interaction effect between gender and ball type in the three-point shooting ability. Both male and female players showed a similar trend in the scoring ability to the ball type, which suggests that the differences in scoring ability is not a mere chance of gender influence but the type of ball used.

The study concludes that the type of material used in balls do influence the three-point shooting in both male and female university players. Therefore, the use of leather balls during training sessions would be beneficial for players as more score during drills would provide more stimulus and motivation. Although the cost of leather balls is on the higher side than other types of ball, the ultimate goal of training is to improve players, and thus the quality of the ball should not be compromised.

Acknowledgements
There are no acknowledgements.

Conflict of Interest
The authors declare that there are no conflicts of interest.

Received: 02 June 2020 | **Accepted:** 29 July 2020 | **Published:** 01 February 2021

References

Button, C., Macleod, M., Sanders, R., & Coleman, S. (2003). Examining movement variability in the basketball free-throw action at different skill levels. *Research Quarterly for Exercise and Sport*, *74*(3), 257–269. https://doi.org/10.1080/02701367.2003.10609090

Connor, J. D., Sinclair, W. H., Leicht, A. S., & Doma, K. (2019). Analysis of Cricket Ball Type and Innings on State Level Cricket Batter's Performance. *Frontiers in psychology*, *10*, 2347. https://doi.org/10.3389/fpsyg.2019.02347

Cooke, K., & Davey, P. R. (2005). Tennis ball diameter: the effect on performance and the concurrent physiological responses. *Journal of Sports Sciences*, *23*(1), 31-39. https://doi.org/10.1080/02640410410001730052

Inaba, Y., Tamaki, S., Ikebukuro, H., Yamada, K., Ozaki, H., & Yoshida, K. (2017). Effect of changing table tennis ball material from celluloid to plastic on the post-collision ball trajectory. *Journal of Human Kinetics*, *55*(1), 29-38. https://doi.org/10.1515/hukin-2017-0004

Julian, G., & Price, J. A. (2017). Keep to the status quo: Analyzing behavioral responses to the change of ball in the NBA. *International Journal of Sport Finance, 12*(2), 93-108.

Knudson, D. (1993). Biomechanics of the basketball jump shot-six key teaching points. *Journal of Physical Education, Recreation, and Dance*, *64*(2), 67–73. https://doi.org/10.1080/07303084.1993.10606710

Malone, L. A., Gervais, P. L., & Steadward, R. D. (2002). Shooting mechanics related to player classification on free throw success in wheelchair basketball. *Journal of Rehabilitation Research and Development*, *39*(6), 701–709.

Mathes, S., & Flatten, K. (1982). Performance characteristics and accuracy in perceptual discrimination of leather and synthetic basketballs. *Perceptual and Motor Skills, 55*(1), 128-13.

Okazaki, V. H. A., Rodacki, A. L. F., & Satern, M. N. (2015). A review on the basketball jump shot. *Sports Biomechanics, 14*(2), 190-205. https://doi.org/10.1080/14763141.2015.1052541

Santos, S., Coutinho, D., Gonçalves, B., Abade, E., Pasquarelli, B., & Sampaio, J. (2020). Effects of manipulating ball type on youth footballers' performance during small-sided games. *International Journal of Sports Science & Coaching*, *15*(2), 170–183. https://doi.org/10.1177/1747954120908003

Guidelines for Authors

Revised September 2019

*** Please use the bookmark function to navigate within the guidelines. ***

When preparing the final version of the manuscripts, either NEW or REVISED authors should strictly follow the guidelines. Manuscripts departing substantially from the guidelines will be returned to the authors for revision or, rejected.

1. UNIFORM REQUIREMENTS

1.1. Overview

The *Sport Mont* (SM) applies the Creative Commons Attribution (CC BY) license to articles and other works it publishes.

The submission with SM is free of charge but author(s) has to pay additional 190 euros per accepted manuscript to cover publication costs. If the manuscript contains graphics in color, note that printing in color is charged additionally.

SM adopts a double-blind approach for peer reviewing in which the reviewer's name is always concealed from the submitting authors as well as the author(s)'s name from the selected reviewers.

SM honors six-weeks for an initial decision of manuscript submission.

Authors should submit the manuscripts as one Microsoft Word (.doc) file.

Manuscripts must be provided either in standard UK or US English language. English standards should be consistent throughout the manuscripts accordingly.

Format the manuscript in A4 paper size; margins are 1 inch or 2.5 cm all around.

Type the whole manuscript double-spaced, justified alignment.

Use Times New Roman font, size eleven (11) point.

Number (Arabic numerals) the pages consecutively (centering at the bottom of each page), beginning with the title page as page 1 and ending with the Figure legend page.

Include line numbers (continuous) for the convenience of the reviewers.

Apart from chapter headings and sub-headings avoid any kind of formatting in the main text of the manuscripts.

1.2. Type & Length

SM publishes following types of papers:

Original scientific papers are the results of empirically- or theoretically-based scientific research, which employ scientific methods, and which report experimental or observational aspects of sports science and medicine, such as all clinical aspects of exercise, health, and sport; exercise physiology and biophysical investigation of sports performance; sport biomechanics; sports nutrition; rehabilitation, physiotherapy; sports psychology; sport pedagogy, sport history, sport philosophy, sport sociology, sport management; and all aspects of scientific support of the sports coaches from the natural, social and humanistic side. Descriptive analyses or data inferences should include rigorous methodological structure as well as sound theory. Your manuscript should include the following sections: Introduction, Methods, Results, and Discussion.

☑Open Submissions ☑Indexed ☑Peer Reviewed

Original scientific papers should be:
- Up to 3000 words (excluding title, abstract, tables/figures, figure legends, Acknowledgements, Conflict of Interest, and References);
- A structured abstract of less than 250 words;
- Maximum number of references is 30;
- Maximum combined total of 6 Tables/Figures.

Review papers should provide concise in-depth reviews of both established and new areas, based on a critical examination of the literature, analyzing the various approaches to a specific topic in all aspects of sports science and medicine, such as all clinical aspects of exercise, health, and sport; exercise physiology and biophysical investigation of sports performance; sport biomechanics; sports nutrition; rehabilitation, physiotherapy; sports psychology; sport pedagogy, sport history, sport philosophy, sport sociology, sport management; and all aspects of scientific support of the sports coaches from the natural, social and humanistic side.

☑Open Submissions ☑Indexed ☑Peer Reviewed

Review papers should be:
- Up to 6000 words (excluding title, abstract, tables/figures, figure legends, Acknowledgements, Conflict of Interest, and References);
- A structured abstract of less than 250 words;
- Maximum number of references is 100.

Editorials are written or commissioned by the editors, but suggestions for possible topics and authors are welcome. It could be peer reviewed by two reviewers who may be external or by the Editorial Board.

☐Open Submissions ☑Indexed ☑Peer Reviewed

Editorials should be:
- Up to 1000 words (excluding title, abstract, tables/figures, figure legends, Acknowledgements, Conflict of Interest, and References);
- A structured abstract of less than 250 words;
- Maximum number of references is 10.

Short reports of experimental work, new methods, or a preliminary report can be accepted as two page papers. Your manuscript should include the following sections: Introduction, Methods, Results, and Discussion.

☑Open Submissions ☑Indexed ☑Peer Reviewed

Short reports should be:
- Up to 1500 words (excluding title, abstract, tables/figures, figure legends, Acknowledgements, Conflict of Interest, and References);
- A structured abstract of less than 250 words;
- Maximum number of references is 15.

Peer review - fair review provides authors who feel their paper has been unfairly rejected (at any journal) the opportunity to share reviewer comments, explain their concerns, and have their paper reviewed for possible publication in SM.

☑Open Submissions ☑Indexed ☐Peer Reviewed

Peer review - fair review should be:
- Up to 1500 words (excluding title, abstract, tables/figures, figure legends, Acknowledgements, Conflict of Interest, and References);
- A structured abstract of less than 250 words;
- Maximum number of references is 15.

Invited papers and award papers include invited papers from authors with outstanding scientific credentials. Nomination of invited authors is at the discretion of the SM editorial board. SM also publishes award papers selected by the scientific committee of the International Scientific Conference on Transformation Processes in Sport.

☐Open Submissions ☑Indexed ☐Peer Reviewed

Invited papers and award papers should be:
- Up to 3000 words (excluding title, abstract, tables/figures, figure legends, Acknowledgements, Conflict of Interest, and References);
- A structured abstract of less than 250 words;
- Maximum number of references is 30;
- Maximum combined total of 6 Tables/Figures.

1.3. Submission

SM only accepts electronic submission to the e-mail of the Journal Office: **sportmont@ucg.ac.me**.

Submitted material includes:

- A manuscript prepared according to the Guidelines for the Authors;
- A signed form that states the study was not previously published, nor has been submitted simultaneously for consideration of publication elsewhere, that states that all of the authors are in agreement with submission of the manuscript to SM, and that, for studies that use animal or human individuals, authors must include information regarding their institution's ethics committee, and which identifies the official approval number;
- A signed form that there is no conflict of interest.

Name the files according to the family name of the first author. Authors submitting revised versions of the manuscript can use the identification number of their manuscript as provided by the Journal Office. *See* example:

- ✓ FAMILY NAME-manuscript.doc – (main manuscript file)
- ✓ FAMILY NAME-statement.PDF – (authorship statement)
- ✓ FAMILY NAME-declaration.PDF – (declaration of potential conflict of interest)
- ✓ FAMILY NAME-fig1.tiff – (Figure 1)

1.4. Peer Review Process

A manuscript submitted for publication will be submitted to the review process as long as it fits the following criteria:

- The study was not previously published, nor has been submitted simultaneously for consideration of publication elsewhere;
- All persons listed as authors approved its submission to SM;
- Any person cited as a source of personal communication has approved the quote;
- The opinions expressed by the authors are their exclusive responsibility;
- The author signs a formal statement that the submitted manuscript complies with the directions and guidelines of SM.

The editors-in-chief and associate editors will make a preliminary analysis regarding the appropriateness, quality, originality and written style/grammar of the submitted manuscript. The editors reserve the right to request additional information, corrections, and guideline compliance before they submit the manuscript to the ad-hoc review process.

SM uses ad-hoc reviewers, who volunteer to analyze the merit of the study. Typically, one or two expert reviewers are consulted in a double-blind process. Authors are notified by e-mail when their submission has been accepted (or rejected). Minor changes in the text may be made at the discretion of the editors-in-chief and/or associate editors. Changes can include spelling and grammar in the chosen language, written style, journal citations, and reference guidelines. The author is notified of changes via email. The final version is available to the author for his or her approval before it is published.

1.5. Open Access License and Publisher Copyright Policies

SM applies the Creative Commons Attribution (CC BY) license to articles and other works it publishes. If author(s) submit its paper for publication by SM, they agree to have the CC BY license applied to their work. Under this Open Access license, the author(s) agree that anyone can reuse their article in whole or part for any purpose, for free, even for commercial purposes. Anyone may copy, distribute, or reuse the content as long as the author(s) and original source are properly cited. This facilitates freedom in re-use and also ensures that SM content can be mined without barriers for the needs of research. On the other hand, the author(s) may use content owned by someone else in their article if they have written permission to do so. If the manuscript contains content such as photos, images, figures, tables, audio files, videos, et cetera, that the author(s) do not own, SM will require them to provide it with proof that the owner of that content has given them written permission to use it, and has approved of the CC BY license being applied to their content. Otherwise, SM will ask the author(s) to remove that content and/or replace it with other content that you own or have such permission to use. SM provides a form the author(s) can use to ask for and obtain permission from the owner.

In addition, the author(s) may freely use the content they previously published in a paper through another publisher and they own the rights to that content; however, that's not necessarily the case and it depends on the license that covers the other paper. Some publishers allow free and unrestricted reuse of article content they own, such as under the CC BY license. Other publishers use licenses that allow reuse only if the same license is applied by the person or publisher reusing the content. If the article was published under a CC BY license or another license that allows free and unrestricted use, the author(s) may use the content in the submitted manuscript provided that the author(s) give proper attribution, as explained above. If the content was published under a more restrictive license, the author(s) must ascertain what rights they have under that license. SM advices the author(s) not to include any content in the submitted manuscript which they do not have rights to use, and always give proper attribution.

The editors of SM consider plagiarism to be a serious breach of academic ethics. Any author who practices plagiarism (in part or totality) will be suspended for six years from submitting new submissions to SM. If such a manuscript is approved and published, public exposure of the article with a printed mark ("plagiarized" or "retracted") on each page of the published file, as well as suspension for future publication for at least six years, or a period determined by the editorial board. Third party plagiarized authors or institutions will be notified, informing them about the faulty authors. Plagiarism will result in immediate rejection of the manuscript.

SM only publishes studies that have been approved by an institutional ethics committee (when a study involves humans or animals). Fail to provide such information prevent its publication. To ensure these requirements, it is essential that submission documentation is complete. If you have not completed this step yet, go to SM website and fill out the two required documents: Declaration of Potential Conflict of Interest and Authorship Statement. Whether or not your study uses humans or animals, these documents must be completed and signed by all authors and attached as supplementary files in the originally submitted manuscript.

1.6. After Acceptance

After the manuscript has been accepted, authors will receive a PDF version of the manuscripts for authorization, as it should look in printed version of SM. Authors should carefully check for omissions. Reporting errors after this point will not be possible and the Editorial Board will not be eligible for them.

Should there be any errors, authors should report them to the Office e-mail address **sportmont@ucg.ac.me**. If there are not any errors authors should also write a short e-mail stating that they agree with the received version.

1.7. Code of Conduct Ethics Committee of Publications

C O P E COMMITTEE ON PUBLICATION ETHICS

SM is hosting the Code of Conduct Ethics Committee of Publications of the **COPE** (the Committee on Publication Ethics), which provides a forum for publishers and Editors of scientific journals to discuss issues relating to the integrity of the work submitted to or published in their journals.

2. MANUSCRIPT STRUCTURE

2.1. Title Page

The first page of the manuscripts should be the title page, containing: title, type of publication, running head, authors, affiliations, corresponding author, and manuscript information. *See* example:

Body Composition of Elite Soccer Players from Montenegro

Original Scientific Paper

Elite Soccer Players from Montenegro

Jovan Gardasevic[1]

[1]Univeristy of Montenegro, Faculty for Sport an Physical Education, Niksic, Montenegro

Corresponding author:

J. Gardasevic

University of Montenegro

Faculty for Sport and Physical Education

Narodne omladine bb, 81400 Niksic, Montenegro

E-mail: jovan@ucg.ac.me

Word count: 2,946

Abstract word count: 236

Number of Tables: 3

Number of Figures: 0

2.1.1. Title

Title should be short and informative and the recommended length is no more than 20 words. The title should be in Title Case, written in uppercase and lowercase letters (initial uppercase for all words except articles, conjunctions, short prepositions no longer than four letters etc.) so that first letters of the words in the title are capitalized. Exceptions are words like: “and”, “or”, “between” etc. The word following a colon (:) or a hyphen (-) in the title is always capitalized.

2.1.2. Type of publication

Authors should suggest the type of their submission.

2.1.3. Running head

Short running title should not exceed 50 characters including spaces.

2.1.4. Authors

The form of an author’s name is first name, middle initial(s), and last name. In one line list all authors with full names separated by a comma (and space). Avoid any abbreviations of academic or professional titles. If authors belong to different institutions, following a family name of the author there should be a number in superscript designating affiliation.

2.1.5. Affiliations

Affiliation consists of the name of an institution, department, city, country/territory (in this order) to which the author(s) belong and to which the presented / submitted work should be attributed. List all affiliations (each in a separate line) in the order corresponding to the list of authors. Affiliations must be written in English, so carefully check the official English translation of the names of institutions and departments.

Only if there is more than one affiliation, should a number be given to each affiliation in order of appearance. This number should be written in superscript at the beginning of the line, separated from corresponding affiliation with a space. This number should also be put after corresponding name of the author, in superscript with no space in between.

If an author belongs to more than one institution, all corresponding superscript digits, separated with a comma with no space in between, should be present behind the family name of this author.

In case all authors belong to the same institution affiliation numbering is not needed.

Whenever possible expand your authors' affiliations with departments, or some other, specific and lower levels of organization.

2.1.6. Corresponding author

Corresponding author's name with full postal address in English and e-mail address should appear, after the affiliations. It is preferred that submitted address is institutional and not private. Corresponding author's name should include only initials of the first and middle names separated by a full stop (and a space) and the last name. Postal address should be written in the following line in sentence case. Parts of the address should be separated by a comma instead of a line break. E-mail (if possible) should be placed in the line following the postal address. Author should clearly state whether or not the e-mail should be published.

2.1.7. Manuscript information

All authors are required to provide word count (excluding title page, abstract, tables/figures, figure legends, Acknowledgements, Conflict of Interest, and References), the Abstract word count, the number of Tables, and the number of Figures.

2.2. Abstract

The second page of the manuscripts should be the abstract and key words. It should be placed on second page of the manuscripts after the standard title written in upper and lower case letters, bold.

Since abstract is independent part of your paper, all abbreviations used in the abstract should also be explained in it. If an abbreviation is used, the term should always be first written in full with the abbreviation in parentheses immediately after it. Abstract should not have any special headings (e.g., Aim, Results…).

Authors should provide up to six key words that capture the main topics of the article. Terms from the Medical Subject Headings (MeSH) list of Index Medicus are recommended to be used.

Key words should be placed on the second page of the manuscript right below the abstract, written in italic. Separate each key word by a comma (and a space). Do not put a full stop after the last key word. *See* example:

Abstract

Results of the analysis of

Key words: *spatial memory, blind, transfer of learning, feedback*

2.3. Main Chapters

Starting from the third page of the manuscripts, it should be the main chapters. Depending on the type of publication main manuscript chapters may vary. The general outline is: Introduction, Methods, Results, Discussion, Acknowledgements (optional), Conflict of Interest (optional). However, this scheme may not be suitable for reviews or publications from some areas and authors should then adjust their chapters accordingly but use the general outline as much as possible.

2.3.1. Headings

Main chapter headings: written in bold and in Title Case. *See* example:
- ✓ **Methods**

Sub-headings: written in italic and in normal sentence case. Do not put a full stop or any other sign at the end of the title. Do not create more than one level of sub-heading. *See* example:
- ✓ *Table position of the research football team*

2.3.2 Ethics

When reporting experiments on human subjects, there must be a declaration of Ethics compliance. Inclusion of a statement such as follow in Methods section will be understood by the Editor as authors' affirmation of compliance: "This study was approved in advance by [name of committee and/or its institutional sponsor]. Each participant voluntarily provided written informed consent before participating." Authors that fail to submit an Ethics statement will be asked to resubmit the manuscripts, which may delay publication.

2.3.3 Statistics reporting

SM encourages authors to report precise p-values. When possible, quantify findings and present them with appropriate indicators of measurement error or uncertainty (such as confidence intervals). Use normal text (i.e., non-capitalized, non-italic) for statistical term "p".

2.3.4. 'Acknowledgements' and 'Conflict of Interest' (optional)

All contributors who do not meet the criteria for authorship should be listed in the 'Acknowledgements' section. If applicable, in 'Conflict of Interest' section, authors must clearly disclose any grants, financial or material supports, or any sort of technical assistances from an institution, organization, group or an individual that might be perceived as leading to a conflict of interest.

2.4. References

References should be placed on a new page after the standard title written in upper and lower case letters, bold.

All information needed for each type of must be present as specified in guidelines. Authors are solely responsible for accuracy of each reference. Use authoritative source for information such as Web of Science, Medline, or PubMed to check the validity of citations.

2.4.1. References style

SM adheres to the American Psychological Association 6th Edition reference style. Check "American Psychological Association. (2009). Concise rules of APA style. American Psychological Association." to ensure the manuscripts conform to this reference style. Authors using EndNote® to organize the references must convert the citations and bibliography to plain text before submission.

2.4.2. Examples for Reference citations

One work by one author
- ✓ In one study (Reilly, 1997), soccer players
- ✓ In the study by Reilly (1997), soccer players
- ✓ In 1997, Reilly's study of soccer players

Works by two authors
- ✓ Duffield and Marino (2007) studied
- ✓ In one study (Duffield & Marino, 2007), soccer players
- ✓ In 2007, Duffield and Marino's study of soccer players

Works by three to five authors: cite all the author names the first time the reference occurs and then subsequently include only the first author followed by et al.

- ✓ First citation: Bangsbo, Iaia, and Krustrup (2008) stated that
- ✓ Subséquent citation: Bangsbo et al. (2008) stated that

Works by six or more authors: cite only the name of the first author followed by et al. and the year

- ✓ Krustrup et al. (2003) studied
- ✓ In one study (Krustrup et al., 2003), soccer players

Two or more works in the same parenthetical citation: Citation of two or more works in the same parentheses should be listed in the order they appear in the reference list (i.e., alphabetically, then chronologically)

- ✓ Several studies (Bangsbo et al., 2008; Duffield & Marino, 2007; Reilly, 1997) suggest that

2.4.3. Examples for Reference list

Journal article (print):

Nepocatych, S., Balilionis, G., & O'Neal, E. K. (2017). Analysis of dietary intake and body composition of female athletes over a competitive season. *Montenegrin Journal of Sports Science and Medicine, 6*(2), 57-65. doi: 10.26773/mjssm.2017.09.008

Duffield, R., & Marino, F. E. (2007). Effects of pre-cooling procedures on intermittent-sprint exercise performance in warm conditions. *European Journal of Applied Physiology, 100*(6), 727-735. doi: 10.1007/s00421-007-0468-x

Krustrup, P., Mohr, M., Amstrup, T., Rysgaard, T., Johansen, J., Steensberg, A., Bangsbo, J. (2003). The yo-yo intermittent recovery test: physiological response, reliability, and validity. *Medicine and Science in Sports and Exercise, 35*(4), 697-705. doi: 10.1249/01.MSS.0000058441.94520.32

Journal article (online; electronic version of print source):

Williams, R. (2016). Krishna's Neglected Responsibilities: Religious devotion and social critique in eighteenth-century North India [Electronic version]. *Modern Asian Studies, 50*(5), 1403-1440. doi:10.1017/S0026749X14000444

Journal article (online; electronic only):

Chantavanich, S. (2003, October). Recent research on human trafficking. *Kyoto Review of Southeast Asia, 4*. Retrieved November 15, 2005, from http://kyotoreview.cseas.kyoto-u.ac.jp/issue/issue3/index.html

Conference paper:

Pasadilla, G. O., & Milo, M. (2005, June 27). *Effect of liberalization on banking competition*. Paper presented at the conference on Policies to Strengthen Productivity in the Philippines, Manila, Philippines. Retrieved August 23, 2006, from http://siteresources.worldbank.org/INTPHILIPPINES/Resources/Pasadilla.pdf

Encyclopedia entry (print, with author):

Pittau, J. (1983). Meiji constitution. In *Kodansha encyclopedia of Japan* (Vol. 2, pp. 1-3). Tokyo: Kodansha.

Encyclopedia entry (online, no author):

Ethnology. (2005, July). In *The Columbia encyclopedia* (6th ed.). New York: Columbia University Press. Retrieved November 21, 2005, from http://www.bartleby.com/65/et/ethnolog.html

Thesis and dissertation:

Pyun, D. Y. (2006). *The proposed model of attitude toward advertising through sport.* Unpublished Doctoral Dissertation. Tallahassee, FL: The Florida State University.

Book:

Borg, G. (1998). *Borg's perceived exertion and pain scales*: Human kinetics.

Chapter of a book:

Kellmann, M. (2012). Chapter 31-Overtraining and recovery: Chapter taken from Routledge Handbook of Applied Sport Psychology ISBN: 978-0-203-85104-3 *Routledge Online Studies on the Olympic and Paralympic Games* (Vol. 1, pp. 292-302).

Reference to an internet source:

Agency. (2007). Water for Health: Hydration Best Practice Toolkit for Hospitals and Healthcare. Retrieved 10/29, 2013, from www.rcn.org.uk/newsevents/hydration

2.5. Tables

All tables should be included in the main manuscript file, each on a separate page right after the Reference section.

Tables should be presented as standard MS Word tables.

Number (Arabic) tables consecutively in the order of their first citation in the text.

Tables and table headings should be completely intelligible without reference to the text. Give each column a short or abbreviated heading. Authors should place explanatory matter in footnotes, not in the heading. All abbreviations appearing in a table and not considered standard must be explained in a footnote of that table. Avoid any shading or coloring in your tables and be sure that each table is cited in the text.

If you use data from another published or unpublished source, it is the authors' responsibility to obtain permission and acknowledge them fully.

2.5.1. Table heading

Table heading should be written above the table, in Title Case, and without a full stop at the end of the heading. Do not use suffix letters (e.g., Table 1a, 1b, 1c); instead, combine the related tables. *See* example:

- ✓ **Table 1.** Repeated Sprint Time Following Ingestion of Carbohydrate-Electrolyte Beverage

2.5.2. Table sub-heading

All text appearing in tables should be written beginning only with first letter of the first word in all capitals, i.e., all words for variable names, column headings etc. in tables should start with the first letter in all capitals. Avoid any formatting (e.g., bold, italic, underline) in tables.

2.5.3. Table footnotes

Table footnotes should be written below the table.

General notes explain, qualify or provide information about the table as a whole. Put explanations of abbreviations, symbols, etc. here. General notes are designated by the word *Note* (italicized) followed by a period.

- ✓ *Note.* CI: confidence interval; Con: control group; CE: carbohydrate-electrolyte group.

Specific notes explain, qualify or provide information about a particular column, row, or individual entry. To indicate specific notes, use superscript lowercase letters (e.g. $^{a, b, c}$), and order the superscripts from left to right, top to bottom. Each table's first footnote must be the superscript ^{a}.

- ✓ ^{a}One participant was diagnosed with heat illness and n = 19.^{b}n =20.

Probability notes provide the reader with the results of the texts for statistical significance. Probability notes must be indicated with consecutive use of the following symbols: * † ‡ § ¶ || etc.

- ✓ *P<0.05,†p<0.01.

2.5.4. Table citation

In the text, tables should be cited as full words. *See* example:

- ✓ Table 1 (first letter in all capitals and no full stop)
- ✓ ...as shown in Tables 1 and 3. (citing more tables at once)
- ✓ ...result has shown (Tables 1-3) that... (citing more tables at once)
- ✓ ....in our results (Tables 1, 2 and 5)... (citing more tables at once)

2.6. Figures

On the last separate page of the main manuscript file, authors should place the legends of all the figures submitted separately.

All graphic materials should be of sufficient quality for print with a minimum resolution of 600 dpi. SM prefers TIFF, EPS and PNG formats.

If a figure has been published previously, acknowledge the original source and submit a written permission from the copyright holder to reproduce the material. Permission is required irrespective of authorship or publisher except for documents in the public domain. If photographs of people are used, either the subjects must not be identifiable or their pictures must be accompanied by written permission to use the photograph whenever possible permission for publication should be obtained.

Figures and figure legends should be completely intelligible without reference to the text.

The price of printing in color is 50 EUR per page as printed in an issue of SM.

2.6.1. Figure legends

Figures should not contain footnotes. All information, including explanations of abbreviations must be present in figure legends. Figure legends should be written bellow the figure, in sentence case. *See* example:

- ✓ **Figure 1.** Changes in accuracy of instep football kick measured before and after fatigued. SR – resting state, SF – state of fatigue, *p>0.01, †p>0.05.

2.6.2. Figure citation

All graphic materials should be referred to as Figures in the text. Figures are cited in the text as full words. *See* example:

- ✓ Figure 1
    - × figure 1
    - × Figure 1.
    - ✓ ….exhibit greater variance than the year before (Figure 2). Therefore…
    - ✓ ….as shown in Figures 1 and 3. (citing more figures at once)
    - ✓ ….result has shown (Figures 1-3) that... (citing more figures at once)
    - ✓ ….in our results (Figures 1, 2 and 5)... (citing more figures at once)

2.6.3. Sub-figures

If there is a figure divided in several sub-figures, each sub-figure should be marked with a small letter, starting with a, b, c etc. The letter should be marked for each subfigure in a logical and consistent way. *See* example:

- ✓ Figure 1a
- ✓ …in Figures 1a and b we can…
- ✓ …data represent (Figures 1a-d)…

2.7. Scientific Terminology

All units of measures should conform to the International System of Units (SI).

Measurements of length, height, weight, and volume should be reported in metric units (meter, kilogram, or liter) or their decimal multiples.

Decimal places in English language are separated with a full stop and not with a comma. Thousands are separated with a comma.

Percentage	Degrees	All other units of measure	Ratios	Decimal numbers
✓ 10%	✓ 10º	✓ 10 kg	✓ 12:2	✓ 0.056
× 10 %	× 10 º	× 10kg	× 12 : 2	× .056

Signs should be placed immediately preceding the relevant number.		
✓ 45±3.4	✓ p<0.01	✓ males >30 years of age
× 45 ± 3.4	× p < 0.01	× males > 30 years of age

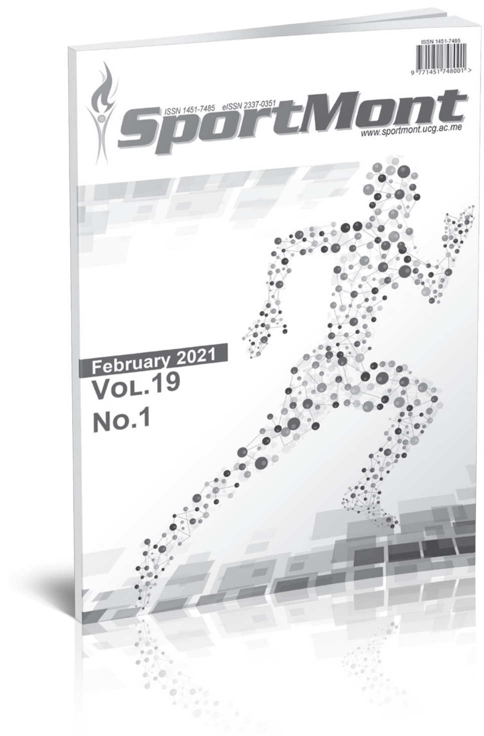
2.8. Latin Names

Latin names of species, families etc. should be written in italics (even in titles). If you mention Latin names in your abstract they should be written in non-italic since the rest of the text in abstract is in italic. The first time the name of a species appears in the text both genus and species must be present; later on in the text it is possible to use genus abbreviations. *See* example:

✓ First time appearing: *musculus biceps brachii*

Abbreviated: *m. biceps brachii*

ISSN 1451-7485 eISSN 2337-0351
SportMont
www.sportmont.ucg.ac.me



ISSN 1451-7485

Sport Mont (SM) is a print (ISSN 1451-7485) and electronic scientific journal (eISSN 2337-0351) aims to present easy access to the scientific knowledge for sport-conscious individuals using contemporary methods. The purpose is to minimize the problems like the delays in publishing process of the articles or to acquire previous issues by drawing advantage from electronic medium. Hence, it provides:

- Open-access and freely accessible online;
- Fast publication time;
- Peer review by expert, practicing researchers;
- Post-publication tools to indicate quality and impact;
- Community-based dialogue on articles;
- Worldwide media coverage.

SM is published three times a year, in February, June and October of each year. SM publishes original scientific papers, review papers, editorials, short reports, peer review - fair review, as well as invited papers and award papers in the fields of Sports Science and Medicine, as well as it can function as an open discussion forum on significant issues of current interest.

SM covers all aspects of sports science and medicine; all clinical aspects of exercise, health, and sport; exercise physiology and biophysical investigation of sports performance; sport biomechanics; sports nutrition; rehabilitation, physiotherapy; sports psychology; sport pedagogy, sport history, sport philosophy, sport sociology, sport management; and all aspects of scientific support of the sports coaches from the natural, social and humanistic side.

Prospective authors should submit manuscripts for consideration in Microsoft Word-compatible format. For more complete descriptions and submission instructions, please access the Guidelines for Authors pages at the SM website: http://www.sportmont.ucg.ac.me/?sekcija=page&p=51. Contributors are urged to read SM's guidelines for the authors carefully before submitting manuscripts. Manuscripts submissions should be sent in electronic format to sportmont@ucg.ac.me or contact following Editors:

Dusko BJELICA, *Editor-in Chief – dbjelica@ucg.ac.me*
Zoran MILOSEVIC, *Editor-in Chief – zoranais@eunet.rs*
Jovan GARDASEVIC, *Managing Editor – jovan@ucg.ac.me*

Publication date: Summer issue – June 2021
Autumn issue – October 2021
Winter issue – February 2022

MONTENEGRIN SPORTS ACADEMY

Founded in 2003 in Podgorica (Montenegro), the Montenegrin Sports Academy (MSA) is a sports scientific society dedicated to the collection, generation and dissemination of scientific knowledge at the Montenegrin level and beyond.

The Montenegrin Sports Academy (MSA) is the leading association of sports scientists at the Montenegrin level, which maintains extensive co-operation with the corresponding associations from abroad. The purpose of the MSA is the promotion of science and research, with special attention to sports science across Montenegro and beyond. Its topics include motivation, attitudes, values and responses, adaptation, performance and health aspects of people engaged in physical activity and the relation of physical activity and lifestyle to health, prevention and aging. These topics are investigated on an interdisciplinary basis and they bring together scientists from all areas of sports science, such as adapted physical activity, biochemistry, biomechanics, chronic disease and exercise, coaching and performance, doping, education, engineering and technology, environmental physiology, ethics, exercise and health, exercise, lifestyle and fitness, gender in sports, growth and development, human performance and aging, management and sports law, molecular biology and genetics, motor control and learning, muscle mechanics and neuromuscular control, muscle metabolism and hemodynamics, nutrition and exercise, overtraining, physiology, physiotherapy, rehabilitation, sports history, sports medicine, sports pedagogy, sports philosophy, sports psychology, sports sociology, training and testing.

The MSA is a non-profit organization. It supports Montenegrin institutions, such as the Ministry of Education and Sports, the Ministry of Science and the Montenegrin Olympic Committee, by offering scientific advice and assistance for carrying out coordinated national and European research projects defined by these bodies. In addition, the MSA serves as the most important Montenegrin and regional network of sports scientists from all relevant subdisciplines.

The main scientific event organized by the Montenegrin Sports Academy (MSA) is the annual conference held in the first week of April.

Annual conferences have been organized since the inauguration of the MSA in 2003. Today the MSA conference ranks among the leading sports scientific congresses in the Western Balkans. The conference comprises a range of invited lecturers, oral and poster presentations from multi- and mono-disciplinary areas, as well as various types of workshops. The MSA conference is attended by national, regional and international sports scientists with academic careers. The MSA conference now welcomes up to 200 participants from all over the world.

It is our great pleasure to announce the upcoming 18th Annual Scientific Conference of Montenegrin Sports Academy "Sport, Physical Activity and Health: Contemporary Perspectives" to be held in Dubrovnik, Croatia, from 8 to 11 April, 2021. It is planned to be once again organized by the Montenegrin Sports Academy, in cooperation with the Faculty of Sport and Physical Education, University of Montenegro and other international partner institutions (specified in the partner section).

The conference is focused on very current topics from all areas of sports science and sports medicine including physiology and sports medicine, social sciences and humanities, biomechanics and neuromuscular (see Abstract Submission page for more information).

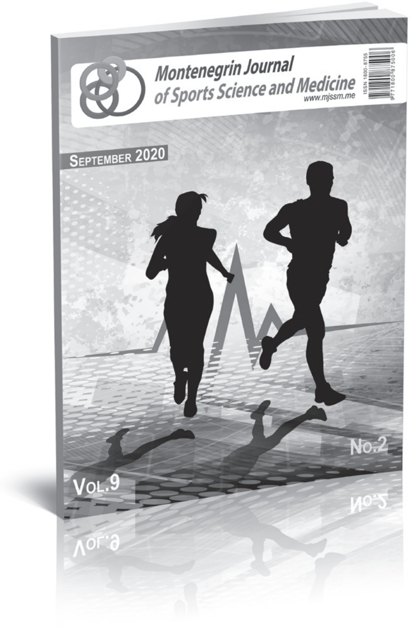
We do believe that the topics offered to our conference participants will serve as a useful forum for the presentation of the latest research, as well as both for the theoretical and applied insight into the field of sports science and sports medicine disciplines.

CRNOGORSKI OLIMPIJSKI KOMITET
MONTENEGRIN OLYMPIC COMMITTEE

BE PART OF OUR TEAM

Montenegrin Journal
of Sports Science and Medicine

MONTENEGRIN JOURNAL OF SPORTS SCIENCE AND MEDICINE



ISSN 1800-8755

CALL FOR CONTRIBUTIONS

Montenegrin Journal of Sports Science and Medicine (MJSSM) is a print (ISSN 1800-8755) and electronic scientific journal (eISSN 1800-8763) aims to present easy access to the scientific knowledge for sport-conscious individuals using contemporary methods. The purpose is to minimize the problems like the delays in publishing process of the articles or to acquire previous issues by drawing advantage from electronic medium. Hence, it provides:
- Open-access and freely accessible online;
- Fast publication time;
- Peer review by expert, practicing researchers;
- Post-publication tools to indicate quality and impact;
- Community-based dialogue on articles;
- Worldwide media coverage.

MJSSM is published biannually, in September and March of each year. MJSSM publishes original scientific papers, review papers, editorials, short reports, peer review - fair review, as well as invited papers and award papers in the fields of Sports Science and Medicine, as well as it can function as an open discussion forum on significant issues of current interest.

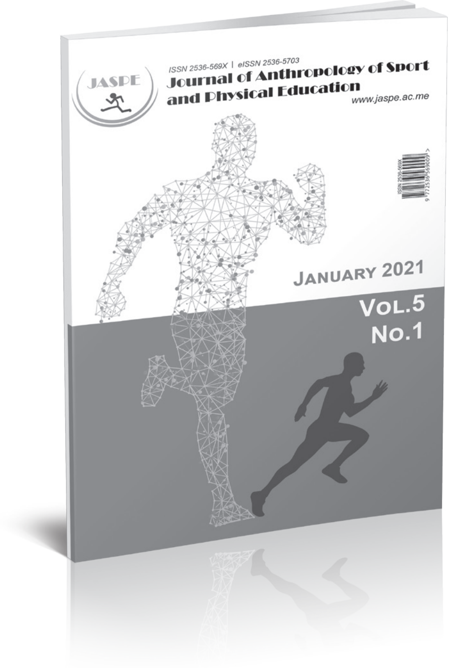
MJSSM covers all aspects of sports science and medicine; all clinical aspects of exercise, health, and sport; exercise physiology and biophysical investigation of sports performance; sport biomechanics; sports nutrition; rehabilitation, physiotherapy; sports psychology; sport pedagogy, sport history, sport philosophy, sport sociology, sport management; and all aspects of scientific support of the sports coaches from the natural, social and humanistic side.

Prospective authors should submit manuscripts for consideration in Microsoft Word-compatible format. For more complete descriptions and submission instructions, please access the Guidelines for Authors pages at the MJSSM website: http://www.mjssm.me/?sekcija=page&p=51. Contributors are urged to read MJSSM's guidelines for the authors carefully before submitting manuscripts. Manuscripts submissions should be sent in electronic format to office@mjssm.me or contact following Editors:

Dusko BJELICA, Editor-in Chief – dbjelica@ucg.ac.me
Stevo POPOVIC, Editor-in Chief – stevop@ucg.ac.me
Selçuk AKPINAR, Executive Editor – sakpinar@nevsehir.edu.tr

Publication date: Spring issue – March 2021
Autumn issue – September 2021

Journal of Anthropology of Sport and Physical Education



ISSN 2536-569X

Journal of Anthropology of Sport and Physical Education (JASPE) is a print (ISSN 2536-569X) and electronic scientific journal (eISSN 2536-5703) aims to present easy access to the scientific knowledge for sport-conscious individuals using contemporary methods. The purpose is to minimize the problems like the delays in publishing process of the articles or to acquire previous issues by drawing advantage from electronic medium. Hence, it provides:

- Open-access and freely accessible online;
- Fast publication time;
- Peer review by expert, practicing researchers;
- Post-publication tools to indicate quality and impact;
- Community-based dialogue on articles;
- Worldwide media coverage.

JASPE is published four times a year, in January, April, July and October of each year. JASPE publishes original scientific papers, review papers, editorials, short reports, peer review - fair review, as well as invited papers and award papers in the fields of Anthropology of Sport and Physical Education, as well as it can function as an open discussion forum on significant issues of current interest.

JASPE covers all aspects of anthropology of sport and physical education from five major fields of anthropology: cultural, global, biological, linguistic and medical.

Prospective authors should submit manuscripts for consideration in Microsoft Word-compatible format. For more complete descriptions and submission instructions, please access the Guidelines for Authors pages at the JASPE website: http://www.jaspe.ac.me/?sekcija=page&p=51. Contributors are urged to read JASPE's guidelines for the authors carefully before submitting manuscripts. Manuscripts submissions should be sent in electronic format to jaspe@ucg.ac.me or contact JASPE's Editor:

Bojan MASANOVIC, *Editor-in Chief – bojanma@ucg.ac.me*

Publication date: Spring issue – April 2021
Summer issue – July 2021
Autumn issue – October 2021
Winter issue – January 2022

CRNOGORSKI OLIMPIJSKI KOMITET
MONTENEGRIN OLYMPIC COMMITTEE

Каталогизација у публикацији
Национална библиотека Црне Горе, Цетиње

ISSN 1451-7485
COBISS.CG-ID 33857808

FIEP Congress

MSA Conference 2021

18th Annual Scientific Conference and 16th FIEP European Congress

Sport, Physical Education, Physical Activity and Health: Contemporary perspectives

http://www.csakademija.me/conference/

CRNOGORSKA SPORTSKA AKADEMIJA

MONTENEGRIN SPORTS ACADEMY

8th - 11th April 2021,
Dubrovnik - Croatia