Montenegrin Journal of Sports Science and Medicine

www.mjssm.me

ISSN 1800-8755

March 2019

Vol.8 No.1

Montenegrin Journal of Sports Science and Medicine

Index Coverage
Web of Science Core Collection (Emerging Sources Citation Index); Scopus; Index Copernicus; DOAJ; SCImago; SPORTDiscus; ERIH PLUS; Open Academic Journals Index; Google Scholar; SHERPA/RoMEO; Crossref; NLM Catalog; Islamic World Science Citation Center (ISC); SafetyLit; Genamics Journal Seek; Ulrich's; Academic Journals Database; InfoBase; J-Gate; OALib; Global Impact Factor; ROAD; UTS: Library; Geisel Guides; Electronic Journal Library; BU Libraries; SMEXE; CiteFactor; Hinari; Scientific Indexing Services; UNB Libraries; UB Leipzig; Geisel Library; EZB; OUM; Universia; UW-Madison Libraries; Kubon & Sagner; UB Online Library; OCLC World Cat; Impact Factor PL; State Library NSW; MIAR

Proofreading Service
Terry Troy Jackson

Prepress
Boris Sundic

Print
Art grafika | Niksic

Print Run
1500

CRNOGORSKA SPORTSKA AKADEMIJA • MONTENEGRIN SPORTS ACADEMY •

UCG
Univerzitet Crne Gore

• Fakultet za sport i fizičko vaspitanje • Univerzitet Crne Gore

ISSN 1800-8755 eISSN 1800-8763

MONTENEGRIN JOURNAL OF SPORTS SCIENCE AND MEDICINE

International Scientific Journal

Vol. 8(2019), No.1 (1-86)

TABLE OF CONTENTS

Full-text available free of charge at http://www.mjssm.me/

Dear Readers,

It gives us enormous pleasure to introduce the first issue of this year's volume of Montenegrin Journal of Sports Science and Medicine (MJSSM). We will, of course, review the achievements for which the past period deserves special attention, but, as MJSSM editors-in-chief, we would also like to bring you a little more personal insight into the reasons why MJSSM is such a great journal.

We have to highlight that our journal continues facing the great success. Even though our Journal has entered two strongest index databases (Web of Science and Scopus), one of these databases (Scopus) continue recognizing the development of our journal that is proved by reaching high impact scores for the first year (CiteScore 2017: 0.60, SJR 2017: 0.167; SNIP 2017: 0.634), while the ongoing tracker is promising a great CiteScore calculation in 2018 (CiteScoreTracker 2018: 3.17; updated on 07 January, 2019) which is scheduled for Spring 2019. On the other hand, we are preparing our journal to be evaluated again by Web of Science in 2020 to reach a long-lasting and eager impact factor and inclusion in SCIE (Science Citation Index Expended) and SSCI (Social Science Citation Index) databases. Therefore, we believe that 2020 will be the year of our highest reach, mostly because we have worked hard and that we deserve further progress and visibility at the international level. Nevertheless, we must keep in mind that this success has not only been achieved by the management of the journal, our editors, reviewers and authors, as well as readers, have contributed equally. For this reason, we want to thank all the participants in the rapid development of our journal, and to invite all those who have not participated before, to join us in the future, to continue in the same rhythm to the same direction.

We would also like to discuss in the introduction speech about the journal statistics. The acceptance rate was almost the same, it was increased for one per cent from last section. Currently, it is on 12% for original research submitted in period 2017-2018 and expected to keep on the same level for the upcoming period. On the other hand, the time from submission to first decision is also a little bit increased (41 days), as well as the time from submission to publication (56 days).

It is enormously important to repeat that our journal will continue working on growing academic publication in the fields 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, in various formats: original papers, review papers, editorials, short reports, peer review - fair review, as well as invited papers and award papers, as well as promote all other academic activities of Montenegrin Sports Academy and Faculty for Sport and Physical Education at University of Montenegro, such as publishing of academic books, conference proceedings, brochures etc.

As we usually do at the end of the introduction speech, we thank our authors one more time, who have chosen precisely our Journal to publish their manuscripts, and we would like to invite them to continue our cooperation to our mutual satisfaction. Thank you all of you for reading us and we hope you will find this issue of MJSSM informative enough.

Editors-in-Chief,
Prof. Dusko Bjelica, PhD
Assoc. Prof. Stevo Popovic, PhD

ORIGINAL SCIENTIFIC PAPER

Respiratory Parameters in Elite Finn-Class Sailors

Luka Pezelj[1], Boris Milavic[2], Marko Erceg[2]

Affiliations: [1]University of Split, Faculty of Maritime Studies, Split, Croatia, [2]University of Split, Faculty of Kinesiology, Split, Croatia

Correspondence: L. Pezelj, University of Split, Faculty of Maritime Studies, Ruđera Boškovića 37, 21000 Split, Croatia. E-mail: luka.pezelj@pfst.hr

ABSTRACT Spirometry is an essential test for assessing the state of the respiratory system. It provides the measurement of the ventilation volumes and flows expressed in absolute and relative values. Among elite athletes, the values of ventilation parameters are usually higher than the norm; therefore the interpretation of individual results of elite athletes in relation to the general healthy population is not advisable. This study aimed to determine the respiratory characteristics of elite sailors in the Olympic Finn class, and the differences between more successful and less successful sailors according to the criterion of sport efficacy. The study included 33 sailors of the Olympic Finn class who participated at the 2015 Finn European Championship. Absolute values of spirometry parameters of elite Finn sailors (FVC-Forced-vital-capacity 5.96±0.79; FEV1-Forced-expiratory-volume-in-1-second 5.10±0.63; FEV1/FVC%-Forced-expiratory-volume-in-1-second/Forced-vital-capacity 86.10±6.38; MVV-Maximum-voluntary-ventilation 190.94±32.64) are higher than the spirometry values of most other athletes. Relative values of spirometry parameters of elite Finn sailors (FVC% 101.24±14.21; FEV1% 102.53±12.09; FEV1/FVC%% 102.00±7.94; MVV% 96.77±18.59) are within the ranges of most elite athletes. Elite sailors can be considered healthy in terms of ventilation, and sailing as a sports activity can be considered beneficial for the ventilatory function of the lungs. More successful sailors had higher mean values of absolute and relative ventilation parameters of FVC, FEV1, and MVV, whereas significant differences were determined in the variables of MVV. The differences between more successful and less successful sailors in the MVV and MVV% variables could be interpreted precisely by the state of respiratory muscles.

KEY WORDS lung volumes, spirometry, Olympic, dinghy, performance, sailing

@MJSSMontenegro
RESPIRATORY PARAMETERS IN ELITE FINN-CLASS SAILORS
http://mjssm.me/?sekcija=article&artid=166

Introduction

Sailing is a very broad term that includes various competitive formats in different sailing classes – from the Optimist, which is intended for children aged 14 years, to the world-renowned events of America's Cup or Volvo Ocean Race. Among the vast variety of competitive sailing forms, sailing in the Olympic classes may be considered the most competitive. Among many other parameters, sailors' aerobic and anaerobic capacity contributes to sailing performance in Olympic sailing (Bojsen-Moller, Larsson & Aagaard, 2014). The main function of the respiratory system is the respiratory gas exchange. By ensuring a sufficient supply of oxygen during exercise, the respiratory system plays a key role in regulating the acid-base homeostasis (McConnell, 2007). Spirometry is an irreplaceable test for assessing the state of the respiratory system. It provides measurements of the ventilation volumes and flows expressed in absolute and relative values (Miller et al., 2005). Relative values of the person's ventilation parameters are calculated as the ratio of the obtained results and the reference value for the general healthy population (Laszlo, 2006). Whether it be the product of the selection process or the effect of the training process, in the population of elite athletes the values of ventilation parameters are usually higher than the norm; consequently, the interpretation of individual results of elite athletes in relation to the general healthy population is not advisable (Cotes, Chinn, & Miller, 2006). Therefore, it is essential to determine the respiratory characteristics of groups of elite athletes in each sport. Numerous studies have been conducted with the aim of comparing the ventilation parameters of athletes and the sedentary healthy population (Doherty & Dimitriou, 1997; Durmic et al., 2017; Jelicic, Uljevic & Zenic, 2017; Lazovic-Popovic et al., 2016; Mazic et al., 2015), to compare groups of athletes involved in different sports (Durmic et al., 2015; Lazovic et al., 2015), to compare different age groups of athletes within the same sport (Foretic, Uljevic, Rogulj, & Marinovic, 2013; Hraste, Lozovina, & Lozovina, 2008), and to compare athletes regarding

Received: March 05 2018 | Accepted after revision: June 02 2018 | First published online: March 01 2019

Conflict of interest: None declared.

their position within the same sport (Ostojic, Mazic & Dikic, 2006). The effect of athletes' respiratory characteristics on their athletic performance was studied by Cular, Milic, Franchini, Ardigo, & Padulo, (2017). In their study, the authors determined that more successful *kumite karateka* in the junior age group had higher absolute values of the ventilation parameters FVC, FEV1, and MVV.

The aim of this study was to determine the respiratory characteristics of elite sailors in the Olympic Finn class, and the differences between more successful and less successful sailors according to the criterion of sport efficacy.

Methods

This study included sailors of the Olympic Finn class who participated at the 2015 Finn European Championship (FEC), in Split. FEC is an "open" competition, and it allows participation of sailors from non-European countries. This FEC included over 60 competitors from almost every continent. Participation in the study was voluntary, and 33 sailors, including the winners of world, continental and national medals, underwent measurement. The sailors were divided into two groups (more successful and less successful) according to their ranking at the World Sailing Rankings (WSR). The WSR is formed by collecting the points from the six most successful competitions for each sailor in the 12 months from the publishing of the table. The WSR is usually published nine times per year. For this study, the authors used the WSR table for the Finn class published on 27th April 2015. The group of more successful sailors included the subjects who were ranked among the first 50 sailors according to the WSR, and the group of less successful sailors included the subjects who were ranked from the 50th to the 329th place of the WSR.

The testing of respiratory characteristics was done using a portable and fully automated microQuark PC-based Spirometer (COSMED, Rome, Italy). The measurement was performed by following the test protocol of Miller et al. (2005). The room where the measurements were taken and the environmental conditions were in accordance with the recommendations from the manufacturer. The following ventilation parameters were measured: FVC (1) – Forced vital capacity, FEV1 (l) - Forced expiratory volume in 1 second, FEV/FVC1% – Forced expiratory volume in 1 second / Forced vital capacity and MVV (l/min) – Maximum voluntary ventilation. No exclusion criteria were applied. In addition to the ventilation parameters, basic morphological variables were also measured: Body height (cm) and Body mass (kg), from which the Body mass index (kg/m^2) was calculated.

All the measurements were taken by the same measurer in the week prior to the competition, in the morning hours before the first training session.

Methods of data analysis included the calculation of basic statistical indicators: Mean, Min - minimum result, Max - maximum result, SD - standard deviation and determination of measures of sensitivity of result distribution: Skew - Skewness, Kurt - Kurtosis, MaxD - maximum distance between relative cumulative theoretical frequency (normal) and relative cumulative empirical frequency (obtained by measuring). Differences between more and less successful sailors were determined using a Student's t-test for independent samples. Data analysis was performed using the Statistica software (ver. 11.00).

The study was approved by the Ethical Board of the Faculty of Kinesiology in Split and conducted with the support of the Executive Committee of the International Finn Association.

Results

The normality of distribution was tested by the Kolmogorov-Smirnov test with the limit value of 0.24, which represents the maximum allowed size of the maximum difference between cumulative and theoretical relative

TABLE 1 Descriptive statistics of age, anthropometric, and respiratory variables of Finn sailors (N=33)

Variables	Mean±SD	Min	Max	Skew	Kurt	maxD
Age (yrs)	25.40±4.26	17.95	33.72	0.35	-0.72	0.09
Body height (cm)	186.51±4.56	176.10	195.80	0.01	0.31	0.09
Body mass (kg)	95.79±7.21	76.30	119.00	0.41	3.62	0.15
Body mass index (kg/m^2)	27.57±2.31	23.66	36.24	1.67	5.35	0.15
FVC (l)	5.96±0.79	4.26	8.10	0.34	0.33	0.09
FVC% (%)	101.24±14.21	78.00	142.00	0.77	0.60	0.12
FEV1 (l)	5.10±0.63	3.60	6.64	0.26	0.63	0.10
FEV1% (%)	102.53±12.09	79.00	141.00	0.85	2.31	0.12
FEV1/FVC%	86.10±6.38	73.70	99.00	-0.06	-0.57	0.12
FEV1/FVC% (%)	102.00±7.94	86.00	116.00	-0.15	-0.68	0.09
MVV (l/min)	190.94±32.64	126.90	257.10	-0.08	0.44	0.15
MVV% (%)	96.77±18.59	63.00	160.00	1.01	3.41	0.13

Note. SD: standard deviation; Min: minimum result; Max: maximum result; Skew: Skewness; Kurt: Kurtosis; maxD: maximum distance between relative cumulative theoretical frequency (normal) and relative cumulative empirical frequency (obtained by measuring). Limit value of KS test for N=33 is 0.24.

DOI 10.26773/mjssm.190301

frequencies. Therefore, none of the measured variables deviated significantly from normal distribution, and they were suitable for further analysis by parametric statistical methods.

Significant differences in arithmetic means between more successful and less successful participants were determined in the Age, MVV, and MVV% variables.

TABLE 2 Differences between more and less successful Finn sailors

Variables	Mean±SD more successful FS (N=18)	Mean±SD less successful FS (N=15)	t-value	p
Age (yrs)	26.85±4.32	23.65±3.57	2.29	0.03
Body height (cm)	187.11±3.72	185.79±5.44	0.83	0.41
Body mass (kg)	97.13±4.18	94.19±9.63	1.17	0.25
Body mass index (kg/m^2)	27.76±1.26	27.34±3.19	0.51	0.61
FVC (l)	6.20±0.75	5.67±0.75	1.99	0.06
FVC% (%)	104.06±15.10	97.87±12.74	1.26	0.22
FEV1 (l)	5.25±0.59	4.89±0.64	1.65	0.11
FEV1% (%)	104.67±12.76	99.79±11.02	1.14	0.26
FEV1/FVC%	85.29±5.77	87.15±7.17	-0.81	0.42
FEV1/FVC% (%)	101.50±7.59	102.64±8.63	-0.40	0.69
MVV (l/min)	204.92±29.20	176.02±30.12	2.71	0.01
MVV% (%)	103.63±18.89	89.47±15.74	2.26	0.03

Note. SD: standard deviation; t-value: ratio between the differences of two arithmetic means; p: level of statistical significance.

Discussion

The more successful sailors were significantly older, which was expected given that the WSR ranking was selected as the criterion of efficacy. The WSR is a ranking system that sums up the rankings of a minimum of six regattas during a season. To achieve the best possible ranking at WSR, a sailor must achieve top results over an extended period, and more experienced sailors will be better at this. Furthermore, younger sailors who have not yet fully asserted themselves in the Finn class, often do not even participate in sufficient numbers of regattas, which are scored for the WSR and are thus further penalized in the final WSR.

In their study, Maisetti, Guevel, Iachkine, Lergos, and Briswalter (2002) presented values of body height and body mass of the participants at the 2000 Olympic Games. The values of body height and body mass recorded for Finn sailors (N=24) in this study were 187±6.00 cm and 97.5±7.5 kg, respectively, which is almost identical to the values of the observed sample.

Ventilation parameters of sailors have not previously been a subject of scientific research; thus, there is no possibility to draw comparisons within the sailing population. However, many other authors have dealt with the problem of ventilation parameters in elite athletes (Durmic et al., 2017; Jelicic et al., 2017; Lazovic-Popovic et al., 2016; Mazic et al., 2015). Mazic et al. (2015) presented absolute and relative values of ventilation parameters for athletes from 15 sports and a control group. Finn sailors showed higher mean absolute values of FVC, FEV1, and MVV than athletes involved in athletics, cycling, cross-country running, soccer, kayak, kickboxing, volleyball, rugby, handball, wrestling, taekwondo, tennis, and the control group. Higher values of FVC, FEV1, and MVV in relation to sailors were recorded in water polo players and rowers. Higher mean values of FVC and FEV1 in relation to Finn sailors were also recorded in the elite junior, sub-elite senior and an elite senior group of rowers (Mikulic, 2008). Lazovic et al. (2015) compared the respiratory characteristics of athletes in different types of sport. In relation to the presented results of absolute values of FVC, FEV1, and MVV, Finn sailors had higher values of FVC and MVV in comparison to athletes in the Skill, Power, Mixed, and Endurance groups of sports, whereas their FEV1 values were almost identical. Given that body height and body mass affect the absolute values of spirometric parameters (Cotes, Chinn, & Miller, 2006), higher absolute values of sailors' ventilation parameters in relation to most other athletes were expected. In contrast, rowers categorized as sub-elite seniors (N=21), aged 22.16±2.8 years, in a study conducted by Mikulic (2008), showed higher values of FVC (7.2±0.7l) and FEV1 (5.6±0.6l), despite the relatively similar values of body height (188.6±5.4cm) and body mass (92.9±5.4kg).

Precisely due to the influence of body height and body mass on the absolute values of ventilation parameters, the relative values of ventilation parameters are more suitable for the comparison (Pellegrino et al., 2005) of different groups of athletes. According to the American Thoracic Society (ATS), a normal spirometry result is considered one with relative values of ventilation parameters that are within 80% of the reference value. Given that sailors' relative ventilation parameters range from 96.77% to 102.53%, sailors can be considered healthy in terms of ventilation, and sailing as a sports activity can be considered beneficial for the ventilatory function of the lungs, which was also confirmed in a study conducted by Jelicic et al., (2017). The aforementioned is

also characteristic for athletes who compete in other sports. However, sailors have lower values of relative ventilation parameters (FVC%, FEV1%, FEV1/FVC%, and MVV) in relation to swimmers (Lazovic-Popovic et al., 2016) and water polo players (Mazic et al., 2015). In these studies, the relative values of FVC, FEV1, FEV1/FVC%, and MVV recorded for swimmers (N=38) aged 20.9±2.4 years were 115.1±12, 112.1±10.2, 96.3±9.4, and 114.9±18.1, respectively, whereas relative values of FVC, FEV1, and MVV recorded for water polo players (N=14) aged 19±4 years were 116.79±16.43, 113.36±15.97, and 143.03±53.36, respectively. As presented in Table 2, more successful sailors had higher mean values of absolute and relative ventilation parameters FVC, FEV1, and MVV, and the morphological parameters BH and BM, whereas significant differences were determined in the variables MVV and age. MVV is defined as the maximum volume of air that can be inhaled and exhaled over a period, usually 12 seconds (Miller et al., 2005), which was set as the time interval in this study. Due to the high correlation between the MVV and FEV1 parameters (Pellegrino et al., 2005), it is thought that MVV does not have to be discretely measured when FEV1 is present (Miller et al., 2005). However, despite the high correlation of FEV1 and MVV, significant differences between more successful and less successful sailors were not determined in the variable FEV1.

As the results of MVV are influenced, among other things, by the weakness and sensitivity of respiratory muscles to fatigue (McConell, 2007), the differences between more successful and less successful sailors in the MVV and MVV% variables could be interpreted precisely by the state of the respiratory muscles of more successful and less successful sailors.

Conclusion

To the authors' knowledge, this is the first paper in which the respiratory characteristics of elite sailors in the Olympic Finn class or any other sailing class, in general, are published. Determining the respiratory characteristics of elite sailors has a role of setting reference values for future research and comparison of sailors' individual results with the results of elite Finn sailors. In this context, the contribution of this paper is significant, but to obtain a more comprehensive picture of the respiratory abilities of elite sailors, spirometric measurements should be performed on sailors competing in other Olympic classes, such as Laser or RSX. The differences between more successful and less successful Finn sailors in the criterion variable of WSR ranking were determined in the MVV and MVV% parameters, whereas in other respiratory parameters, the differences were not found. This also justifies future application of the MVV spirometric test, which, along with FVC, FEV1, and FEV1/FVC, can provide a clearer image of athletes' respiratory abilities. The obtained differences in the MVV variable between more successful and less successful sailors may indicate that there are differences in the states of respiratory muscles. Thus, it would be advisable for future studies to include the tests assessing the functions of respiratory muscles, in addition to spirometric tests. Although useful, the WSR ranking is not a sufficient measure for assessing competitive efficacy. The authors believe that a repeated measurement, with placement at elite sports competition as the criterion variable, would additionally contribute to understanding the importance of respiratory parameters on success in sailing.

Acknowledgements

The authors gratefully acknowledge the support and help of the International Finn Association and the Labud Yacht Club.

REFERENCES

Bojsen-Møller, J., Larsson B., & Aagaard, P. (2014). Physical requirements in Olympic sailing. *European Journal of Sport Science, 15*(3), 220-227. doi: 10.1080/17461391.2014.955130

Cotes, J. E., Chinn, D. J., & Miller M. R. (2006). *Lung Function: Physiology, Measurement and Application in Medicine* (6th ed.): Blackwell Publishing.

Cular, D., Milic, M., Franchini, E., Ardigo, L.P., & Padulo, J. (2017). Pulmonary function is related to success in junior elite kumite karatekas. *Sport Science, 10*(1), 117-122.

Doherty, M., & Dimitriou, L. (1997). Comparison of lung volume in Greek swimmers, land based athletes, and sedentary controls using allometric scaling. *British Journal of Sports Medicine, 31*(4), 337-341.

Durmic, T., Lazovic, B., Djelic, M., Suzic-Lazic, J., Zikic, D., Zugic, V., … Mazic, S. (2015). Sport-specific influences on respiratory patterns in elite athletes. *Jornal Brasileiro de Pneumologia, 41*(6), 516-522. http://dx.doi.org/10.1590/S1806-37562015000000050

Durmic, T., Lazovic-Popovic, B., Zlatkovic-Svenda, M., Djelic, M., Zugic, V., Gavrilovic, T., … Leischik, R. (2017). The training type influence on male elite athletes' ventilatory function. *BMJ Open Sport & Exercise Medicine 3*(1), e000240. doi:10.1136/bmjsem-2017-000240

Foretic, N., Uljevic, O., Rogulj, N., & Marinovic, M. (2013). Pulmonary function of different age category handball players. *Hrvatski športskomedicinski vjesnik [Croatian Sports Medicine Journal], 28*(1), 47–51.

Hraste, M., Lozovina, V., & Lozovina, M. (2008). The Effect of Long-Term Training on Static and Dynamic Lungs Volumes and Capacities of Young Water-Polo Players. *Naše more, 55*(3-4), 153-159.

Jeličic, M., Uljevic, O., & Zenic, N. (2017). Pulmonary Function in Prepubescent Boys: The Influence of Passive Smoking and Sports. *Montenegrin Journal of Sports Science and Medicine, 6*(1), 65-72.

Laszlo, G. (2006). Standardisation of lung function testing: helpful guidance from the ATS/ERS Task Force.

DOI 10.26773/mjssm.190301

Thorax, 61(9), 744–746. doi: 10.1136/thx.2006.061648

Lazovic, B., Mazic, S., Suzic-Lazic, J., Djelic, M., Djordjevic-Saranovic, S., Durmic, T., … Zugic, V. (2015). Respiratory adaptations in different types of sport. *European Review for Medical and Pharmacological Sciences, 19*(12), 2269-2274.

Lazovic-Popovic, B., Zlatkovic-Svenda, M., Durmic, T., Djelic, M., Djordjevic-Saranovic, S., & Zugic, V. (2016). Superior lung capacity in swimmers: Some questions, more answers! *Revista portugesa de pneumologia, 22*(3), 151-156.

Maisetti, O., Guevel, A., Iachkine, P., Lergos, P., & Briswalter, J. (2002). Sustained hiking position in dinghy sailing. Theoretical aspects and methodological considerations for muscle fatigue assessment. *Science et sports, 17*(5), 234–246.

Mazic, S., Lazovic, B., Djelic, M., Suzic-Lazic, J., Djordjevic-Saranovic, S., Durmic, T., … Zugic, V. (2015). Respiratory parameters in elite athletes - does sport have an influence? *Revista portugesa de pneumologia, 21*(4), 192-197.

McConell, A. (2007). Chapter 8 -Lung and respiratory muscle function: Chapter taken from Sport and exercise physiology testing guidelines, ISBN: 0–415–37965–2, The British Association of Sport and Exercise Sciences Guide, Exercise and Clinical Testing (Vol. 2, pp. 63-75).

Mikulic, P. (2008). Anthropometric and physiological profiles of rowers of varying ages and ranks. *Kinesiology, 40*(1), 80-88.

Miller, M.R., Hankinson, J., Brusasco, V., Burgos, F., Casaburi, R., Coates, A., … Wanger, J. (2005). Standardisation of spirometry, ATS/ERS Task Force**:** standardisation of lung function testing**.** *European Respiratory Journal, 26*(2), 319-338. doi: 10.1183/09031936.05.00034805

Ostojic, S.M., Mazic, S., & Dikic, N. (2006). Profiling in basketball: physical and physiological characteristics of elite players. *Journal of Strength and Conditioning Research, 20*(4), 740-744.

Pellegrino, R., Viegi, G., Brusasco, V., Crapo, R.O., Burgos, F., Casaburi, R., … Wanger, J. (2005). Interpretative strategies for lung function tests. *European Respiratory Journal, 26*(5), 948-968. doi: 10.1183/09031936.05.00035205

Renzetti Jr, A. D., Bleecker, E. R., Epler, G. R., Jones, R. N., Kanner, R. E., & Repsher, L. H. (1986). Evaluation of impairment/disability secondary to respiratory disorders. *American Review of Respiratory Disease*, *133*(6), 1205-1209.

ORIGINAL SCIENTIFIC PAPER

Comparison of the Static and Dynamic Balance Between Normal-Hearing and Hearing-Impaired Wrestlers

Betul Coskun[1], Gurcan Unlu[1], Bahman Golshaei[1], Settar Kocak[1], Sadettin Kirazci[1]

Affiliations: [1]Middle East Technical University, Faculty of Education, Department of Physical Education and Sports, Ankara, Turkey

Correspondence: B. Coskun, Middle East Technical University, Department of Physical Education and Sports, 06800 Cankaya/Ankara, Turkey. E-mail: bcoskun@metu.edu.tr

ABSTRACT Balance is fundamental in sport, especially when there is an opponent. Although balance can be improved with practice, it is highly affected by nervous system disorders, particularly by vestibular disorders and visual impairment. The purpose of this study was to compare static and dynamic balance between normal and hearing-impaired wrestlers. The participants were 52 young male hearing-impaired wrestlers (n=29, age=18.76±3.54) and normal-hearing athletes (n=23, age=19.09±2.76) competing at the national level. The static and dynamic balance were measured using the stork test on one foot and the Y-balance test (in anterior, posteromedial & posterolateral directions). MANOVA indicated significant differences between groups (Wilks' L=.284, $F_{12,39}$=8.21, p<.05, η^2=.72). Differences were detected in how long the participant had been active in the sport F(year) ($F_{1,50}$=145.95, p<.025, η^2=.75) and right leg static balance ($F_{1,50}$=73.63, p<.025, η^2=.60). As for the Y balance test, there was also a significant difference in the anterior direction for the right leg ($F_{1,50}$=4880.66, p<.025, η^2=.99) and left leg ($F_{1,50}$=3563.87, p<.025, η^2=.99). Hearing-impaired wrestlers performed better balance abilities in the dynamic balance test of right and left legs in the anterior direction. In contrast, the amount of time active in the sport and the static balance of the right leg were found better in normal-hearing wrestlers. Being better than normal wrestlers only in the anterior direction of the dynamic balance might be due to the differences related to the directions of the test. Future studies are recommended for investigating the reasons for this difference.

KEY WORDS balance, hearing-impaired, wrestlers

@MJSSMontenegro
THE STATIC AND DYNAMIC BALANCE BETWEEN WRESTLERS
http://mjssm.me/?sekcija=article&artid=167

Introduction

Balance is the task of keeping the position of the centre of gravity of the body vertical, and then performing coordinated and precise neuromuscular activities based on the fast and sustained feedback from visual, vestibular, and somatosensory constructions (Hrysomallis, 2011). Static balance is the skill of sustaining a base of support with minimum movement. Dynamic balance is the skill of executing an action while maintaining a stable position or the skill of sustaining one's balance on an unstable surface (Bressel, Yonker, Kras, & Heath, 2007; Hrysomallis, 2011).

Balance, the precursor of voluntary motor activity, requires the efficient operation and interaction of vestibular, proprioceptive, motor and visual neurophysiological mechanisms (McLeod & Hansen, 1989), in that it is an act of integrating sensory input from various sources to provide static and dynamic postures (Fotiadou et al., 2002). For the completion of balance, a combination of sensory, vestibular, visual, proprioceptive systems, the central nervous system, and the musculoskeletal system is needed (Winter, Patla, & Frank, 1990). The proprioceptive system is composed of muscles, joints and cutaneous receptors. It gives information about the effector system from muscles and other body parts, and also about the environment (Winter et al., 1990). Input from the eyes provides information about how the individual is positioned in respect to the surrounding objects and about the position and movement of the head (Hosseinimehr, Norasteh, Abbasi, Tazji, & Hosseinimehr, 2009;

Received: March 03 2018 | Accepted after revision: April 05 2018 | First published online: March 01 2019

Conflict of interest: None declared.

Vestibular Disorder Association (VEDA), 2008). As for the sensory information related to movement, balance, and spatial orientation, it is provided by vestibular organs: the saccule, the utricle, and three semi-circular canals in the ear. While the saccule and utricle perceive the gravity and linear motion, the semi-circular canals specify the rotational movements. The balance information acquired from these peripheral sensory organs is transmitted to the brain stem. Then, it is analysed and integrated with learned information with the contributions of the cerebellum and the cerebral cortex (VEDA, 2008), and the proper movement plan is performed by the musculoskeletal system to organize the action and body posture (Winter et al., 1990).

This complexity of the balance system promotes the detection and treatment of the underlying reasons of balance disorders, and vestibular disorders are in the lead as a reason (VEDA, 2008). Therefore, studies with hearing impairments have gained importance. Hearing-impaired individuals, in comparison to normal-hearing ones, are more vulnerable with regards to static balance, dynamic coordination of the body, simultaneous movements of limbs and movement speed (Effgen, 1981; Fotiadou et al., 2002; Kitiş, Büker, Eren, & Aydın, 2015; Wiegersma & Velde, 1983; Yağcı, Cavlak, & Şahin, 2004). This impaired balance may affect the acquisition of other motor skills and may hinder visual-perceptual motor development and sensory integration (Effgen, 1981). However, sport is a recommended method for reducing these negative effects, facilitating daily life activities and the rehabilitation of hearing-impaired individuals (Yağcı et al., 2004). Balance is fundamental, especially in combat sports, in which the balance is kept against the opponent (El Rendimiento, 2015; Leong, Fu, Ng, & Tsang, 2011; Perrin, Deviterne, Hugel, & Perrot, 2002; Perrot, Mur, Mainard, Barrault, & Perrin, 2000). In Olympic wrestling, athletes must effectively maintain their static and dynamic balance due to the techniques of this sport which are based on changing of location, pushing and pulling in order to disturb the opponent's balance (El Rendimiento, 2015). Therefore, the balance of athletes is better than sedentary individuals especially in combat sports (Bieć & Kuczyński, 2010; Filingeri, Bianco, Zangla, Paoli, & Palma, 2012; Leong et al., 2011; Perrin et al., 2002; Perrot, Moes, Deviterne, & Perrin, 1998). However, although the balance can be improved by sports, it is highly affected by nervous system disorders, visual impairment, fatigue and mental conditions and, as stated previously, particularly by vestibular disorders (Fotiadou et al., 2002; Yağcı et al., 2004). Therefore, the purpose of this study is to compare static and dynamic balance between normal and hearing-impaired wrestlers.

Methods

Participants

Fifty-two young male wrestlers, including hearing-impaired (n=29, age=18.76±3.54 years) and normal-hearing athletes (n=23, age=19.09±2.76 years), who are athletes on the Turkish National Team voluntarily participated in the study. Thus, a purposive sampling method was used. All participants completed informed consent forms. The human research ethics committee at the Middle East Technical University approved the study. Both groups consisted of freestyle and Greco-Roman wrestlers in junior and senior categories. Information about their age, height, weight, the amount of time active in the sport and previous injuries was obtained from participants and reviewed. Those who had been injured in the previous three months were excluded from the study.

Procedures

The measurements of both groups were taken at the same time of day and on days when there was no wrestling training. Short warm-up times were given to the participants before starting to test. Then static balance was measured by using the stork test on one foot. The participant removed his shoes, placed his hands on his waist, and placed the unsupported leg towards the interior of the knee of the support leg. He was asked to lift his heel from the floor and try to balance on tiptoe. The stopwatch was started when the heel was removed from the floor. The researcher stood behind the participant due to the possibility of the latter's losing his balance and falling. Participants were warned not to lower their hands and not to turn their support leg in any direction or to bounce. Furthermore, it was said that the test would be stopped when there was a disconnection between the unsupported leg and knee, and when the heel of the support leg touched the ground. To make a comparison, both sides, right and left, were evaluated. It was tested two times for both feet, and the best value was recorded in seconds (Reiman & Manske, 2009).

As for the dynamic balance, the Y-Balance Test (YBT) was used. It is a test to measure the dynamic balance in unilateral standing and a variation of the Star Excursion Balance Test. The participant tried to reach in the anterior, posteromedial, and posterolateral directions while standing on one foot at the exact centre of the test platform. Both left and right legs were tested when barefoot. Participants were allowed four trials, then measurements were performed three times in all directions. The participants were asked to try to reach as far as possible with one foot while standing on the other foot just behind the start line. To accomplish the measurement, participants were warned not to lower their test-foot before returning to the stance-position and not to try to speed up to reach further. Furthermore, they were instructed that the trial would be regarded as invalid if they stepped on the reach point to get support or if they lost their balance before returning to the starting position. The average of the three trials was normalized to leg length. Also, the reach distances in three directions were summed to determine the total performance of both feet. The rest interval time between trials was sufficient for the reach distance to be recorded and for starting once again (Butler, Southers, Gorman, Kiesel, & Plisky, 2012).

DOI 10.26773/mjssm.190302

Statistical analysis

The statistics of variables were reported by using mean and standard deviation. The normality of distribution was tested with a Shapiro-Wilk test. To compare the differences in balance parameters between the normal-hearing and hearing-impaired groups, One-way Multivariate Analysis of Variance (One-way MANOVA) was used. IBM SPSS Statistics v22.0 was used for statistical data analyses. Alpha value was accepted as 0.05.

Results

There are significant differences between the groups (Wilks' L=.284, $F_{12,39}$=8.21, p<.05, η^2=.72) (Table 2). One of these differences was detected in the amount of time active in the sport (year) ($F_{1,50}$=145.95, p<.025, η^2=.75) (Table 1).

TABLE 1 Comparison of Groups' Demographic Characteristics

Variable	Group	n	X±SS	F	p	η2
Age (year)	Hearing-impaired	29	18,76±3,54	,13	,717	,003
	Normal-hearing	23	19,09±2,76			
Height (cm)	Hearing-impaired	29	171,41±8,79	4,51	,039	,08
	Normal-hearing	23	176,22±7,14			
Weight (kg)	Hearing-impaired	29	70,72±17,75	5,03	,029	,09
	Normal-hearing	23	82,52±20,13			
Time active in the sport (year)	Hearing-impaired	29	4,43±4,02	11,82	,001**	,19
	Normal-hearing	23	7,96±3,18			

Note. **p<0.025

TABLE 2 One-Way MANOVA Test Results

Variable	λ	F	df	Error df	p	η2
Hearing impairment	,284	8,21	12	39	,001*	,72

Note. λ: Wilks' Lambda, *p<0.05

Furthermore, a significant difference was found in the static balance of the right leg ($F_{1,50}$=73.63, p<.025, η^2=.60) (Table 3). As for the Y-balance test, there was also a significant difference in the anterior direction for the right leg ($F_{1,50}$=4880.66, p<.025, η^2=.99) and the left leg ($F_{1,50}$=3563.87, p<.025, η^2=.99) (Table 3).

TABLE 3 Comparison of Groups' Static and Dynamic Balance Results

Variable	Group	n	X±SS	F	p	η2
Static right	Hearing-impaired	29	4,59±3,31	12,62	,001**	,20
	Normal-hearing	23	11,08±9,13			
Static left	Hearing-impaired	29	6,30±6,81	3,50	,067	,07
	Normal-hearing	23	10,06±7,67			
Right anterior	Hearing-impaired	29	91,39±8,91	19,30	,001**	,28
	Normal-hearing	23	80,57±8,70			
Left anterior	Hearing-impaired	29	94,33±9,03	31,59	,001**	,39
	Normal-hearing	23	78,10±11,81			
Right posteromedial	Hearing-impaired	29	135,39±18,94	,16	,692	,00
	Normal-hearing	23	133,65±10,12			
Left posteromedial	Hearing-impaired	29	139,80±19,47	1,04	,314	,02
	Normal-hearing	23	135,15±11,31			
Right posterolateral	Hearing-impaired	29	126,77±21,10	,23	,633	,01
	Normal-hearing	23	129,04±9,27			
Left posterolateral	Hearing-impaired	29	129,94±19,23	,71	,403	,01
	Normal-hearing	23	133,67±9,94			
Right total performance	Hearing-impaired	29	353,55±43,01	1,05	,310	,02
	Normal-hearing	23	343,27±24,09			
Left total performance	Hearing-impaired	29	364,08±41,11	2,96	,091	,06
	Normal-hearing	23	346,91±27,36			

Note. **p<0.025

Discussion

The study aimed to determine whether the hearing impairment makes a difference in the static and dynamic balance of elite wrestlers. Significant differences were found between the groups of wrestlers with and without hearing impairment. Normal-hearing athletes were found to be better in terms of the amount of time they had been active in the sport and static balance measured with the right foot. In a study conducted on hearing-impaired male volleyball and handball players, a significant difference was found in the balance scores of the groups in favour of the volleyball players, and this difference was thought to be due to the structure of volleyball and the greater amount of time they had been active in the sport, which is similar in the present study (Taşkın, Karakoç, & Yüksek, 2015). In another study made on hearing-impaired and normal-hearing children, the hearing-impaired ones were found to be significantly weaker than normal-hearing ones in static balance (Shaikh & Sadhale, 2013). A different study was conducted on three different groups as hearing-impaired sedentary and football players and normal-hearing football players. It was found that normal-hearing football players were better in static balance performance than hearing-impaired football players were (Eliöz, Sitti, Koç, Murt, & Koç, 2013). Yağcı et al. (2004) carried out a study on children with and without hearing impairment and evaluated the balance scores by use of dynamic and static balance tests on stable and unstable surfaces. They concluded that normal-hearing group had the best scores while the group with congenital hearing impairment had the lowest scores. Studies indicate that hearing-impaired individuals have the weaker balance ability than normal-hearing ones, especially in static balance (Tan, Nonis, & Chow, 2011) and the present study findings, are consistent with the literature in this respect. Because deafness can affect the psychomotor integration of the central nervous system and impair motor skills like balance (Lindsey & O'Neal, 1976), it was thought that the weaker static balance of the hearing-impaired group was due to their hearing impairment. Additionally, it might be influenced by the lower amount of time active in the sport and also the difference just in the right foot measurement may be related to the dominant side of the groups.

As for the dynamic balance, it was found that hearing-impaired wrestlers had better balance abilities just in the anterior direction in both right and left leg measurements. In the literature, while some studies show no significant differences between hearing-impaired and normal-hearing groups (Gayle & Pohlman, 1990; Melo, Silva, Tassitano, Macky, & Silva, 2012; Nakajima, Kaga, Takekoshi, & Sakuraba, 2012), studies showing significant differences are also available (Gayle & Pohlman, 1990; Kitiş et al., 2015; Tan et al., 2011; Yağcı et al., 2004). However, these differences are generally in favour of the normal-hearing group. The present study differs from the literature in this respect. For instance, in a different study, there was a significant difference in favour of the normal-hearing group in the balance to the left and toward the front, and also in total balance, while there was no significant difference in the balance scores to the right and backwards. It was thought that the reason for this non-existence of difference to the right and backwards was due to the fact that 70% of the participants in the hearing-impaired group had regular exercise habits and only 24.1% of the participants in the normal-hearing group were regularly exercising (Kitiş et al., 2015). However, in the present study, both groups are athletes from the Turkish National Team, so the exercise factor is not considered to be a reason for this difference.

It is not correct to say that the loss of balance in hearing-impaired individuals is due solely to vestibular system impairment; other factors need to be considered (Wiegersma & Velde, 1983; Yağcı et al., 2004). For instance, in another study, there was no significant difference between the groups in the one-leg standing test with eyes open; however, when performing the same test with eyes closed, the duration of standing was markedly shorter in the hearing-impaired group (Nakajima et al., 2012). When hearing impairment occurs, other sensory perceptions work to recompense the deficit (Nakajima et al., 2012; Siegel, Marchetti, & Tecklin, 1991). Likewise, in another study conducted by using the one-leg-standing test with eyes closed, hearing-impaired individuals were found to be particularly weaker in balance (Tan et al., 2011). The underlying reason was thought to be the visual system. To control and maintain the balance depend on the inputs from visual, vestibular and somatosensory systems, and the combination of these systems within the environment. Studies showed that removing the visual stimulus negatively affects the hearing-impaired individuals more as they attempt to control their balance (Tan et al., 2011). As for the present study, the existence of significant differences in dynamic balance in favour of the hearing-impaired group may be due to the fact that other sensory systems improved much better to compensate for this deficit, also caused by the differences of strength, flexibility, and the dominant side. Especially for the anterior direction, better performances of dynamic balance test (Star Excursion Balance Test) were found related to the greater hip flexor, extensor, and abductor strength (Ambegaonkar, Mettinger, Caswell, Burtt, & Cortes, 2014). In other respects, the weaker static balance but better dynamic balance ability, which was performed by the hearing-impaired group, may be explained with the source of the hearing impairment, since the saccule and utricle perceive the gravity and linear motion, while the semi-circular canals specify the rotational movements (Vestibular Disorder Association (VEDA), 2008).

Consequently, for hearing-impaired wrestlers, being better than normal-hearing wrestlers in the only anterior direction of the dynamic balance might be due to the differences related to the directions of the test and the differences of strength. The reasons for this difference should be investigated in future studies. Therefore, future studies are advised to take extra measurements such as strength and flexibility with balance tests and to obtain information about the dominant side of the participants.

DOI 10.26773/mjssm.190302

Acknowledgements

The abstract of this study was presented as an oral presentation at the 14th International Sports Sciences Congress in Turkey.

REFERENCES

Ambegaonkar, J. P., Mettinger, L. M., Caswell, S. V., Burtt, A., & Cortes, N. (2014). Relationships between core endurance, hip strength, and balance in collegiate female athletes. *International Journal of Sports Physical Therapy*, *9*(5), 604-616.

Bieć, E., & Kuczyński, M. (2010). Postural control in 13-year-old soccer players. *European Journal of Applied Physiology, 110*(4), 703-708.

Bressel, E., Yonker, J. C., Kras, J., & Heath, E. M. (2007). Comparison of static and dynamic balance in female collegiate soccer, basketball, and gymnastics athletes. *Journal of Athletic Training, 42*(1), 42.

Butler, R. J., Southers, C., Gorman, P. P., Kiesel, K. B., & Plisky, P. J. (2012). Differences in soccer players' dynamic balance across levels of competition. *Journal of Athletic Training*, 47(6), 616-620.

Effgen, S. K. (1981). Effect of an exercise program on the static balance of deaf children. *Physical Therapy, 61*(6), 873-877.

El Rendimiento, E. L. O. (2015). Can balance skills predict Olympic wrestling performance?. *Journal of Sport and Health Research, 7*(1), 19-30.

Eliöz, M., Sitti, S., Koç, M. C., Murt, Z., & Koç, H. (2013). A Study on Static Balance Performance of Healthy and Hearing-Impaired Football Players. *European Journal of Applied Sciences*, *5*(1), 25-28.

Filingeri, D., Bianco, A., Zangla, D., Paoli, A., & Palma, A. (2012). Is karate effective in improving postural control?. *Science of Martial Arts. 8*(4), 191-4.

Fotiadou, E., Giagazoglou, P., Kokaridas, D., Angelopoulou, N., Tsimaras, V., & Tsorbatzoudis, C. (2002). Effect of rhythmic gymnastics on the dynamic balance of children with deafness. *European Journal of Special Needs Education*, 17(3), 301-309.

Gayle, G. W., & Pohlman, R. L. (1990). Comparative study of the dynamic, static, and rotary balance of deaf and hearing children. *Perceptual and Motor Skills*, *70*(3), 883-888.

Hosseinimehr, S. H., Norasteh, A. A., Abbasi, A., Tazji, M. K., & Hosseinimehr, S. H. (2009). The comparision of dependency on vision and proprioception in gymnastic, wrestling and soccer. *Brazilian Journal of Biomotricity*, 3(4), 332-338.

Hrysomallis, C. (2011). Balance ability and athletic performance. *Sports Medicine, 41*(3), 221-232.

Kitiş, A., Büker, N., Eren, K. E., & Aydın, H. (2015). İşitme engelli kişilerde statik dengeyi etkileyen faktörlerin incelenmesi. *Journal of Kartal Training & Research Hospital, 26*(1).

Leong, H. T., Fu, S. N., Ng, G. Y., & Tsang, W. W. (2011). Low-level Taekwondo practitioners have better somatosensory organisation in standing balance than sedentary people. *European Journal of Applied Physiology, 111*(8), 1787-1793.

Lindsey, D., & O'Neal, J. (1976). Static and dynamic balance skills of eight year old deaf and hearing children. *American Annals of the Deaf*, 49-55.

McLeod, B., & Hansen, E. (1989). Effects of the eyerobics visual skills training program on static balance performance of male and female subjects. *Perceptual and Motor Skills, 69*(3 suppl), 1123-1126.

Melo, R. D. S., Silva, P. W. A. D., Tassitano, R. M., Macky, C. F. S., & Silva, L. V. C. D. (2012). Balance and gait evaluation: comparative study between deaf and hearing students. *Revista Paulista de Pediatria*, *30*(3), 385-391.

Nakajima, Y., Kaga, K., Takekoshi, H., & Sakuraba, K. (2012). Evaluation of vestibular and dynamic visual acuity in adults with congenital deafness. *Perceptual and Motor Skills*, *115*(2), 503-511.

Perrin, P., Deviterne, D., Hugel, F., & Perrot, C. (2002). Judo, better than dance, develops sensorimotor adaptabilities involved in balance control. *Gait and Posture, 15*(2), 187-194.

Perrot, C., Moes, R., Deviterne, D., & Perrin, P. (1998). Postural adaptations during specific combative sport movements. *Science and Sports, 2*(13), 64-74.

Perrot, C., Mur, J. M., Mainard, D., Barrault, D., & Perrin, P. H. (2000). Influence of trauma induced by judo practice on postural control. *Scandinavian Journal of Medicine and Science in Sports, 10*(5), 292-297.

Reiman, M. P., & Manske, R. C. (2009). *Functional testing in human performance*. Human Kinetics.

Shaikh, A. A., & Sadhale, A. (2013). Motor proficiency in hearing impaired and healthy children: a comparison. *International Journal of Current Research and Review*, *5*(11), 57.

Siegel, J. C., Marchetti, M., & Tecklin, J. S. (1991). Age-related balance changes in hearing-impaired children. *Physical Therapy*, *71*(3), 183-189.

Tan, J. S. Y., Nonis, K. P., & Chow, J. Y. (2011). The balance control of children with and without hearing impairment in Singapore–A case study. *International Journal of Special Education*, 26(3).

Taşkın, C., Karakoç, Ö., & Yüksek, S. (2015). İşitme engelli voleybol ve hentbol erkek sporcuların statik denge performans durumlarının incelenmesi. *The Journal of Academic Social Science, 3*(17), 248-255.

Vestibular Disorder Association. (2008). The human balance system: A complex coordination of central and peripheral systems. Retrieved from www.vestibular.org

Wiegersma, P. H., & Velde, A. V. (1983). Motor development of deaf children. *Journal of Child Psychology and Psychiatry, 24*(1), 103-111.

Winter, D. A., Patla, A. E., & Frank, J. S. (1990). Assessment of balance control in humans. *Medical Progress Through Technology*, 16(1-2), 31-51.

Yağcı, N., Cavlak, U., & Şahin, G. (2004). İşitme engellilerde denge yeteneğinin incelenmesi üzerine bir çalışma. *Kulak, Burun, Boğaz ve Baş, Boyun Cerrahisi Dergisi, 3*(2), 45-50.

DOI 10.26773/mjssm.190302

ORIGINAL SCIENTIFIC PAPER

Exponential versus linear tapering in junior elite soccer players: effects on physical match performance according to playing positions

Marino Krespi[1], Goran Sporis[2], Stevo Popovic[3]

Affiliations: [1]University of Split, Faculty of Kinesiology, Split, Croatia, [2]University of Zagreb, Faculty of Kinesiology, Zagreb, Croatia, [3]University of Montenegro, Faculty for Sport and Physical Education, Nikšić, Montenegro

Correspondence: G. Sporis, University of Zagreb, Faculty of Kinesiology, Horvaćanski zavoj 15, 10110, Zagreb, Croatia. E-mail: sporis.79@gmail.com

ABSTRACT The purpose of the present study was to investigate the effects of exponential and linear tapering protocols on the distance covered according to playing positions among junior elite soccer players. One-hundred and fifty-eight junior elite soccer players (mean age: 17.07±0.79 years; mean height: 177.85±6.64 cm; mean weight: 71.27±7.96 kg; mean body-mass index: 22.50±1.66 kg/m^2) were randomly selected into two groups: (1) exponential and (2) linear tapering group. Training sessions were conducted three times a week for eight weeks. After four and eight weeks of the tapering period, participants were measured in the distance covered according to four basic playing positions on the field: (1) goalkeepers, (2) defenders, (3) midfielders, and (4) forwards. The results showed that the largest effects between the pre- and post-measurement had defenders in the exponential and goalkeepers in the linear group, goalkeepers in the distance covered by slow and medium running in both groups, forwards in fast running and sprinting in the exponential group, and midfielders in the linear group. In conclusion, our results suggest that the exponential tapering protocol brought somewhat larger effects, especially in fast running and sprinting in forwards and slow and medium running in goalkeepers. Future studies need to implement both the exponential and the linear tapering protocols in order to enhance performance but favouring the exponential to produce larger effects.

KEY WORDS tapering, soccer, juniors, situational efficiency, effects

Introduction

The game of soccer is often described as a team and contact sport characterized by different running intensities, jumps, acceleration and deceleration, and tackling (Valter Di Salvo et al., 2007; Valter Di Salvo, Gregson, Atkinson, Tordoff, & Drust, 2009). Previous studies have shown that senior elite players cover between 10,500 and 12,000 metres per soccer match, with around 10% of high-intensity activities (Dellal et al., 2011; Dellal et al., 2010). Junior soccer players, however, cover between 9,000 and 10,000 meters per soccer match, have lower heart rate responses (82% vs 93% in senior players) and blood lactate concentrations (Wong et al., 2008). Additionally, a few studies have found positional differences between players, especially in the anthropometric characteristics and different physiological demands of each player (Bloomfield, Polman, & O'Donoghue, 2007; Rampinini, Coutts, Castagna, Sassi, & Impellizzeri, 2007). In general, midfielders cover a greater distance than other players on different playing positions, whereas forwards perform more sprinting activities and defenders dribble a shorter distance (Rampinini et al., 2007).

Over the past two decades, numerous studies have recorded activities performed by the players in different playing positions, aimed to discover which physical match activities are most important for soccer requirements (Buchheit et al., 2014; Valter Di Salvo et al., 2009; Fessi et al., 2016; Sarmento et al., 2014). The physiological and psychological requirements for soccer can be achieved through training load reduction (Inigo Mujika & Padilla, 2003). Training load reduction, i.e. reduction of the physiological and psychological load

Received: June 02 2018 | Accepted after revision: June 15 2018 | First published online: March 01 2019

Conflict of interest: None declared.

before the competition period, is known as "tapering" (Inigo Mujika & Padilla, 2003). The tapering protocol may improve and enhance performance in both athletes from individual and team sports (Bosquet, Montpetit, Arvisais, & Mujika, 2007; Elloumi et al., 2012). Previous findings have shown that a high training load during the training period could impair performance (Slattery, Wallace, Bentley, & Coutts, 2012). In general, it has been proposed that training load should decrease in order to reduce the frequency and volume of training but not the intensity (Bosquet et al., 2007).

To the best of our knowledge and after an extensive literature review, there has only been one study investigating the effects of the tapering protocol on physical match performance in soccer players (Fessi et al., 2016). Their results showed large effect changes in intensity running, high-intensity running, high-speed running activities, and the number of sprints between the standard and the taper week in favour of the taper week. However, there has been no study investigating the effects of two different tapering protocols on physical match performance in soccer players. Neither has there been a study investigating those effects according to different playing positions. Thus, the main purpose of the present study was to investigate the effects of the exponential and linear tapering protocol on distance covered according to playing positions in junior elite soccer players.

Methods

Participants

One-hundred and fifty-eight (N=158) elite Croatian junior soccer players (mean age: 17.07±0.79 yrs.; mean height: 177.85±6.64 cm; mean weight: 71.27±7.96 kg; mean body-mass index: 22.50±1.66 kg/m^2, mean training experience: 9.42±1.54 years) were randomly selected into the exponential tapering group and linear tapering group. Randomization was done with replacement, in which each participant had an equal chance of being selected. There were 14 forwards, 18 defenders, 40 midfielders, and 7 goalkeepers in the exponential group and 15 forwards, 13 defenders, 45 midfielders, and 6 goalkeepers in the linear taper group. Basic descriptive statistics of the study participants in the distance-covered variables are presented in Table 2. Before the study began, each participant gave assent, and their parents/guardians had given informed consent to participate in the study. All participants were told about potential risks during the study. During the study, participants were not allowed to be in another training program that could potentially bias the results. All the procedures performed in this study were in accordance to the Declaration of Helsinki and were approved by the Institutional Review Board of the Faculty of Kinesiology, University of Split, Croatia.

Match activities

With the Focus 3 analyser system, we also included the distance covered by players during the soccer match and categorized this into five classes: (1) walking/jogging (0.4-3.0 km/h), slow running (3.0-8.0 km/h), medium running (8.0-13.0 km/h), fast running (13-18 km/h) and sprint (>18 km/h). We also included total distance covered, as a sum of all categories combined. All the results were expressed in metres.

Testing protocol

In the first phase of the study, in agreement with soccer clubs, all the measurements were done in the morning period between 9.00-12.00 h. Two days before the testing, the participants did not have any type of training with significant load, which could potentially affect the results. All variables within the study were measured three times: the initial, transitive and final periods. The transitive measurement was done four weeks after the initial measurement. After the transitive measurement, both experimental groups underwent different tapering protocols: linear or exponential. Training for both groups was held three sessions per week and consisted of 4×4 min running exercises with the intensity of 90-95% heart rate$_{max}$ separated with a four-minute jogging period of 40% heart rate$_{max}$. The tapering protocol lasted for four weeks, followed by final measurement. In total, the whole protocol lasted for eight weeks. It is noteworthy that coaches used the same training methods of teaching. Furthermore, all participants had similar levels of physical activity outside the testing period and had similar diet protocols. Detailed protocols of both tapers are presented in Table 1.

TABLE 1 Training protocol for both tapers (3×/week, 4×4 min of running to from 90-95% heart ratemax)

Linear tapering		Exponential tapering	
Weeks	**Series × minutes**	**Weeks**	**Series × minutes**
1	4×4	1	4×4
1	3×4	1	2×4
1	2×4	1	1 ×4
1	1×4	1	1×4
Pause 4 minutes – 40% of heart rate$_{max}$		Pause 4 minutes – 40% of heart rate$_{max}$	

Statistical analysis

Basic descriptive parameters are presented as means ± standard deviations. To assess whether the data were normally distributed, a Kolmogorov-Smirnov test was used. To test if the main effect of the factor *Group* (exponential vs linear), the factor *Position* (goalkeepers vs defenders vs midfielders vs forwards), the factor *Time* (pre-test, mid-test, and post-test) and the factorial interactions *Group×Position, Group×Time, Position×Time*

DOI 10.26773/mjssm.190303

and Group×Position×Time were significant, a 3-factorial between-between-within 2×4×3 ANOVA was used. Homogeneity of variance was tested by using Leven's test, and differences between groups and trials were determined by using the Bonferroni correction. Data have been identified as outliers if was out of M ± 2σ interval. Partial-eta squared (partial η^2) was used for effect size assessment. Statistical analyses were performed by using the Statistical Package for Social Sciences software (SPSS ver. 23). Type one error was set at α=5%.

Results

First, we calculated the coefficient of variation (CV) for every variable measured three times. Results showed small variation between three measurements in height (CV=0.001), sitting height (CV=0.002), weight (CV=0.002), body-mass index (CV=0.004), % of fat-mass (CV=0.006), % water (CV=0.001) and % of muscle mass (CV=0.002). In motor abilities, the results in CV showed somewhat larger variations in 5 m sprint (CV=0.083), 10 m sprint (CV=0.059), 30 m sprint (CV=0.025), 96369 agility test (CV=0.023), repeated sprint ability (CV=0.018), squat jump (CV=0.033) and squat jump with arm swing (CV=0.029). Last, in functional abilities, results in VO2max showed small CV (0.012). Basic descriptive statistics of the study participants are presented in Table 2. As shown, defenders and midfielders had the biggest distance covered, opposed to forwards and goalkeepers (p<0.05). Midfielders covered around 2000 metres in medium running, yet midfielders and forwards covered approximately 400 m by sprinting. In the distance covered by walking/jogging,

TABLE 2 Basic descriptive statistics of the study participants (N=158)

Study variables	Exponential tapering group			Linear tapering group		
	Pre	Mid	Post	Pre	Mid	Post
	mean±SD	mean±SD	mean±SD	mean±SD	mean±SD	mean±SD
Walking/jogging (0.4-3.0 km/h)						
Forwards	5418.08±259.50	5465.38±279.00	5535.77±290.45*	5449.33±248.44	5514.00±247.75	5603.33±229.86*†
Midfielders	5461.27±219.14	5508.67±186.20	5577.33±186.29*	5404.61±207.67	5471.54±208.96	5528.46±201.56*†
Defenders	5576.15±201.04	5639.49±211.26	5724.87±213.95*	5577.11±209.54	5628.67±201.22	5707.33±186.05*
Goalkeepers	2392.86±235.28	2465.71±243.37	2554.28±245.21*	2456.67±189.44	2510.66±180.66	2633.33±136.63*†
Slow running (3.0-8.0 km/h)						
Forwards	1369.23±225.03	1415.38±229.73	1480.38±209.77*	1293.33±228.24	1358.00±224.70	1433.73±212.03*
Midfielders	1514.86±256.81	1597.24±256.32	1679.22±233.59*	1582.56±253.05	1620.12±240.33	1736.07±247.48*†
Defenders	1466.67±284.52	1549.87±269.02	1648.33±233.27*	1419.23±186.57	1478.46±205.18	1563.54±202.32*†
Goalkeepers	964.28±85.21	1035.71±109.22	1078.57±116.11*	948.33±105.91	991.67±114.79	1058.33±113.03*
Medium running (8.0-13.0 km/h)						
Forwards	1715.38±343.62	1764.61±259.28	1856.92±235.70*	1680.00±265.11	1694.67±257.93	1781.33±233.75*†
Midfielders	1878.38±360.66	1935.00±361.20	2011.35±358.47	1797.62±447.17	1817.14±445.31	1862.38±441.97
Defenders	1802.50±456.18	1858.12±463.35	1930.00±446.39	1765.38±377.15	1812.31±376.30	1886.92±367.39
Goalkeepers	977.14±109.14	1064.28±143.51	1152.86±142.79*	1002.00±177.46	1086.83±190.51	1124.67±190.48
Fast running (13.0-18.0 km/h)						
Forwards	628.57±113.87	684.28±121.15	745.35±132.61*	700.00±146.38	724.33±139.60	760.67±143.45*
Midfielders	667.57±154.66	704.49±149.43	765.57±155.70*	670.29±157.22	706.01±151.10	768.44±154.30*
Defenders	714.70±132.01	758.82±134.48	822.94±134.76*	719.23±152.12	764.61±154.68	831.54±144.48*
Goalkeepers	528.57±108.52	561.43±114.23	612.86±102.91*	566.67±101.65	590.00±105.99	636.67±109.53*
Sprinting (>18 km/h)						
Forwards	402.86±159.15	448.57±158.54	517.50±167.82*	410.00±113.39	426.67±118.06	464.70±121.00*†
Midfielders	407.50±150.87	451.40±149.13	516.25±153.27*	404.44±144.53	442.00±147.14	501.78±148.19*
Defenders	382.35±138.00	424.41±139.68	472.06±138.46*	401.55±166.02	446.92±155.59	493.85±160.86*
Goalkeepers	242.86±97.50	279.28±99.93	295.71±95.01	226.67±106.90	247.50±103.85	286.87±107.07*
Total distance covered						
Forwards	9561.12±2096.54	9678.22±2347.94	10035.92±2216.51	9532.66±2071.39	9717.67±2159.84	10043.73±2232.64
Midfielders	9655.50±1613.38	9868.87±1799.03	10219.92±1862.33	9857.36±1810.85	10092.75±2020.95	10401.73±2469.01
Defenders	9940.37±1745.84	10228.57±1847.30	10596.14±2178.27	9881.66±1698.26	10128.30±1985.90	10480.39±2150.18
Goalkeepers	5103.13±334.70	5404.24±477.48	5721.37±420.90*	5198.56±358.07	5424.65±415.12	5737.28±426.17*

Note. *-significant difference between mid and post-test; †- Significant difference between groups

the effect size between pre- and post- measurement ranged within 0.43 in forwards to 0.72 in defenders in the exponential group, and between 0.60 in midfielders and 1.07 in goalkeepers. In the slow and medium running variable, the biggest changes occurred in goalkeepers in both the exponential and linear groups between pre- and post-measurement. However, forwards in the exponential group enhanced their results between pre- and post-measurement (ES=0.95) in the distance covered by fast running than forwards in the linear group did (ES=0.41). The largest effect size occurred in forwards and midfielders in the exponential group between the pre- and post-measurement and in midfielders in the linear tapering group. Defenders and midfielders in both the exponential and linear tapering groups had the largest distance covered during the game: between 10,000 and 10,500 meters.

The interaction between groups (exponential vs. linear), playing positions (forwards, midfielders, defenders, and goalkeepers) and time (pre-, mid-, and post-) showed no statistically significant result ($F=0.486$; $p=0.819$; $\eta^2=0.010$) for distance covered by walking/jogging, also by distance covered by low running ($F=1.274$; $p=0.269$; $\eta^2=0.027$) and total distance covered ($F=1.090$; $p=0.368$; $\eta^2=0.021$). However, significant results occurred in the distance covered by medium running ($F=2.299$; $p=0.022$; $\eta^2=0.051$), where there were significant differences between forwards, midfielder and defenders opposed to goalkeepers. The interaction between groups (exponential vs. linear), playing positions (forwards, midfielders, defenders and goalkeepers) and time (pre-, mid- and post-) showed a statistically significant effect ($F=3.739$; <0.001; $\eta^2=0.074$) in the distance covered by fast running. Specifically, goalkeepers had the lowest time changes in contrast to forwards, midfielders, and defenders, while no significant differences occurred between those three playing positions ($p>0.05$). In the distance covered by sprinting, results showed significant effects in the interaction between time and playing positions ($F=4.350$; $p<0.001$; $\eta^2=0.093$), time and tapering group ($F=11.240$; $p<0.001$; $\eta^2=0.196$) and time, playing positions, and tapering groups ($F=5.944$; $p<0.001$; $\eta^2=0.153$).

Discussion

The purpose of the present study was to investigate the effects of exponential and linear tapering protocols on the distance covered according to playing positions in junior elite soccer players. Our results showed significant improvements following both linear and exponential tapering periods in soccer players in all playing positions. As mentioned by some previous studies, it is difficult to analyse match performance only through distance covered, since soccer represents a highly complex game (Coutts, Chamari, Rampinini, & Impellizzeri, 2008). However, our results are in accordance with some previous studies, which have reported certain aerobic enhancements in both individual sport athletes (Costill, King, Thomas, & Hargreaves, 1985; Inigo Mujika & Padilla, 2003; Sanchez et al., 2013) and team sport athletes (Coutts et al., 2008; Elloumi et al., 2012). In one of the most recent studies, the results showed that maximal oxygen uptake increased after a two-week tapering program in the experimental group of soccer players (Fortes, Vianna, Silva, Gouvêa, & Cyrino, 2016). It has been previously established that maximal oxygen uptake enhancements occur due to activation of the PGC-1α complex related to carbohydrates and fats control and enhancing fat and glucose oxidation, which can potentially improve aerobic endurance (Silva & Araújo, 2015). Similar physiological changes by following a tapering period have been reported in other sports, like kayaking (García-Pallarés, Sanchez-Medina, Pérez, Izquierdo-Gabarren, & Izquierdo, 2010), cycling (Neary, Martin, & Quinney, 2003), swimming (Trappe, Costill, & Thomas, 2001), and running (I Mujika et al., 2002). Moreover, tapering has been shown to increase oxygen extraction important for aerobic activities (Neary et al., 2003), to reduce muscle damage and catabolism, and to enhance anabolism and muscle glycogen stores (Coutts et al., 2008).

Next, our results showed that forwards had the largest changes between pre- and post-measurement in the exponential group, followed by defenders, yet the largest differences were observed in defenders in the linear group in the fast running variable. Similar findings were obtained in sprinting activities. Since this is the first study examining the effects of two different types of tapering on the distance covered during the soccer match, we concentrated on physiological and playing position demands required by each player. For example, findings have proved that forwards perform the most maximal sprints and for longer durations, along with higher levels of stopping and faster deceleration activities (Bloomfield et al., 2007). Furthermore, forwards are more engaged in actions that require specific activities, like jumping and heading the ball (Reilly, 2003). It is possible that forwards improved their performance, since studies have shown that velocity, agility, and speed are the most important characteristics during a soccer match (Gil, Gil, Ruiz, Irazusta, & Irazusta, 2007). Moreover, morphologically, they are much leaner and stronger players with somewhat better physiological characteristics than the other players on different playing positions, indicating that the result of the game primarily depends on the forwards group (Gil et al., 2007).

Along with forwards, midfielders showed the largest changes in sprinting activities. This could be explained by the fact that midfielders are engaged in significantly less walking and low running intensities, but spend the most time in running and sprinting activities (Bloomfield et al., 2007). Studies have also shown that midfielders have higher levels of maximal oxygen uptake (VO2max) and cover greater distances in contrast to the players in other playing positions (Reilly, Bangsbo, & Franks, 2000).

Goalkeepers were shown to produce the largest changes in walking/jogging and slow running activities in our study, which could be related to the fact that they perform the poorest in the endurance tests (Tumilty, 1993). Defenders in our study had the largest changes in slow running in contrast to other playing positions. In gen-

DOI 10.26773/mjssm.190303

eral, time changes in our study according to playing position could be explained by different playing roles on the field during the soccer match. Since different requirements are needed from each player, we speculate that both tapering protocols produce different effect changes. For example, goalkeepers mostly cover distance with walking/jogging and low intensity running. Since they use such activities the most, it is possible that tapering influenced the most specifically on those parameters. Moreover, similar values were obtained among forwards and midfielders, who had the largest changes in fast running and sprinting activities, especially in the exponential group. One meta-analysis has shown that training load reduction between 40-60% from maximal load in a period of two weeks causes the largest improvements in performance (Bosquet et al., 2007). This kind of training load reduction seems to have beneficial effects against muscle fatigue and training stress during the tapering period. Furthermore, we only looked at physical soccer match parameters, but not on psychological parameters. Future studies should take both physiological and psychological parameters into account, since previous findings have shown that certain monotony is related to the onset of overtraining combined with high training loads (Foster, 1998).

Our study has several limitations. First, we did not control for diet and other physical activities of the participants during the tapering period, which may potentially lead to bias. However, all the participants were instructed prior to the study to have somewhat similar diet and not to participate in other sport activities. Second, we did not analyse technical and tactical elements during the soccer match, along with the psychological abilities. It is necessary to establish the relation between technical-tactical elements and distance covered in different running intensities (Fessi et al., 2016).

In conclusion, our results show that both the exponential and linear tapering protocols improved distance covered by different running intensities in soccer players according to their playing positions. However, the exponential tapering protocol brought somewhat larger change effects, especially in forwards and midfielders in fast running and sprinting activities during the soccer match. Furthermore, results suggest that goalkeepers had the biggest improvements in distance covered by walking/jogging and low running, since their playing role requires this kind of activity. As mentioned before, future studies should focus on investigating how different tapering protocols may affect physical and psychological abilities and sport-specific (technical and tactical) elements during the soccer match.

Avoiding overtraining and optimizing performance could be achieved through the logical variation of training methods and volume loads. As mentioned earlier, a taper involves a reduction in the physiological and psychological stress, which could potentially enhance performance. Our results showed that decreasing the 5% of initial values or 5% of the previous session values in every forthcoming workout had similar effects on distance covered by different running intensities in soccer players according to their playing positions. However, forwards and midfielders in fast running and sprinting activities during the soccer match showed better improvements following the exponential tapering. The novel finding in the current study is that sprinting during matches was increased after exponential tapering in junior soccer players. However, caution is advised when interpreting the results of this study, bearing in mind the complexity and the various factors that could influence physical match activities. Our results confirmed the reports of others, which suggest that volume is the optimal variable to manipulate exponentially, i.e., reducing the volume of training while maintaining both the intensity and the frequency of sessions.

REFERENCES

Bloomfield, J., Polman, R., & O'Donoghue, P. (2007). Physical demands of different positions in FA Premier League soccer. *Journal of Sports Science & Medicine, 6*(1), 63.

Bosquet, L., Montpetit, J., Arvisais, D., & Mujika, I. (2007). Effects of tapering on performance: a meta-analysis. *Medicine and Science in Sports and Exercise, 39*(8), 1358.

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.

Costill, D. L., King, D. S., Thomas, R., & Hargreaves, M. (1985). Effects of reduced training on muscular power in swimmers. *The Physician and Sportsmedicine, 13*(2), 94-101.

Coutts, A., Chamari, K., Rampinini, E., & Impellizzeri, F. (2008). Monitoring training in football: measuring and periodising training. *From training to performance in soccer. Paris, France: De Boeck Universite*, 242-263.

Dellal, A., Chamari, K., Wong, d. P., Ahmaidi, S., Keller, D., Barros, R., . . . Carling, C. (2011). Comparison of physical and technical performance in European soccer match-play: FA Premier League and La Liga. *European Journal of Sport Science, 11*(1), 51-59.

Dellal, A., Keller, D., Carling, C., Chaouachi, A., Wong, d. P., & Chamari, K. (2010). Physiologic effects of directional changes in intermittent exercise in soccer players. *The Journal of Strength & Conditioning Research, 24*(12), 3219-3226.

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.

Elloumi, M., Makni, E., Moalla, W., Bouaziz, T., Tabka, Z., Lac, G., & Chamari, K. (2012). Monitoring Training Load and Fatigue in Rugby Sevens Players. *Asian Journal of Sports Medicine, 3*(3), 175-184.

Fessi, M. S., Zarrouk, N., Di Salvo, V., Filetti, C., Barker, A. R., & Moalla, W. (2016). Effects of tapering on physical match activities in professional soccer players. *Journal of sports sciences, 34*(24), 2189-2194.

Fortes, L. d. S., Vianna, J. M., Silva, D. M. d. S., Gouvêa, M. A. d., & Cyrino, E. S. (2016). Effects of tapering on maximum aerobic power in indoor soccer players. *Revista Brasileira de Cineantropometria & Desempenho Humano, 18*(3), 341-352.

Foster, C. (1998). Monitoring training in athletes with reference to overtraining syndrome. *Medicine and Science in Sports and Exercise, 30*, 1164-1168.

García-Pallarés, J., Sanchez-Medina, L., Pérez, C. E., Izquierdo-Gabarren, M., & Izquierdo, M. (2010). Physiological effects of tapering and detraining in world-class kayakers. *Medicine & Science in Sports & Exercise, 42*(6), 1209-1214.

Gil, S. M., Gil, J., Ruiz, F., Irazusta, A., & Irazusta, J. (2007). Physiological and anthropometric characteristics of young soccer players according to their playing position: relevance for the selection process. *Journal of Strength and Conditioning Research, 21*(2), 438.

Mujika, I., Goya, A., Ruiz, E., Grijalba, A., Santisteban, J., & Padilla, S. (2002). Physiological and performance responses to a 6-day taper in middle-distance runners: influence of training frequency. *International Journal of Sports Medicine, 23*(05), 367-373.

Mujika, I., & Padilla, S. (2003). Scientific bases for precompetition tapering strategies. *Medicine and Science in Sports and Exercise, 35*(7), 1182-1187.

Neary, J. P., Martin, T. P., & Quinney, H. A. (2003). Effects of taper on endurance cycling capacity and single muscle fiber properties. *Medicine and Science in Sports and Exercise, 35*(11), 1875-1881.

Rampinini, E., Coutts, A. J., Castagna, C., Sassi, R., & Impellizzeri, F. (2007). Variation in top level soccer match performance. *International Journal of Sports Medicine, 28*(12), 1018-1024.

Reilly, T. (2003). Motion analysis and physiological demands. *Science and soccer, 2*, 59-72.

Reilly, T., Bangsbo, J., & Franks, A. (2000). Anthropometric and physiological predispositions for elite soccer. *Journal of sports sciences, 18*(9), 669-683.

Sanchez, A. M., Galbès, O., Fabre-Guery, F., Thomas, L., Douillard, A., Py, G., . . . Candau, R. B. (2013). Modelling training response in elite female gymnasts and optimal strategies of overload training and taper. *Journal of sports sciences, 31*(14), 1510-1519.

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

Silva, C. G., & Araújo, C. G. S. (2015). Sex-specific equations to estimate maximum oxygen uptake in cycle ergometry. *Arquivos Brasileiros de Cardiologia, 105*(4), 381-389.

Slattery, K. M., Wallace, L. K., Bentley, D. J., & Coutts, A. J. (2012). Effect of training load on simulated team sport match performance. *Applied Physiology, Nutrition, and Metabolism, 37*(2), 315-322.

Trappe, S., Costill, D., & Thomas, R. (2001). Effect of swim taper on whole muscle and single muscle fiber contractile properties. *Medicine and Science in Sports and Exercise, 33*(1), 48-56.

Tumilty, D. (1993). Physiological characteristics of elite soccer players. *Sports Medicine, 16*(2), 80-96.

Wong, P., Mujika, I., Castagna, C., Chamari, K., Lau, W. C., & Wisloff, U. (2008). Characteristics of World Cup soccer players. *Soccer Journal-Binghamton-National Soccer Coaches Association of America, 53*(1), 57.

DOI 10.26773/mjssm.190303

ORIGINAL SCIENTIFIC PAPER

Fathers – An Untapped Resource for Increasing Physical Activity among African American Girls

Tara B. Blackshear[1]

Affiliations: [1]Towson University, Department of Kinesiology, Towson, MD, USA

Correspondence: T. B. Blackshear, Towson University, Department of Kinesiology, 8000 York Rd, Towson, MD 21204, USA. E-mail: tblackshear@towson.edu

ABSTRACT African American girls' physical activity significantly declines during adolescence. Single mothers are raising many African American girls. Research on the benefits of fathers' involvement on physical activity is minimal, especially regarding girls. The current study examines the impact that fathers' involvement and family structure have on physical activity behaviours among African American adolescent girls (n=40). Data were collected via a demographic questionnaire, a father involvement scale, and a leisure time exercise instrument. Data were analysed via descriptive statistics, analysis of variance, and multiple regression. African American girls' physical activity habits are positively associated with involved fathers. Girls reporting high father involvement had higher rates of physical activity than girls reporting low father involvement did. Girls from two-parent families had higher physical activity rates than girls in single-parent households, but these findings were non-significant. Fathers being actively engaged in physical activities was a significant predictor of physical activity among the study population. Fathers demonstrating nurturing and participatory behaviours, irrespective of residential or biological status, may be instrumental in promoting physical activity among African American adolescent girls. Physical activity programming targeting African American girls should include fathers and other male figures, as they may be instrumental in keeping African American girls physically active.

KEY WORDS parental involvement, exercise, African American families, health promotion

@MJSSMontenegro
FATHERS & PHYSICAL ACTIVITY
http://mjssm.me/?sekcija=article&artid=169

Introduction

Physical activity (PA) levels have been shown to sharply decline during adolescence, and this trend continues over the lifespan (Center for Disease Control and Prevention [CDC], 2012). The benefits of PA are widely known and include risk reduction for heart disease, diabetes, obesity, some cancers, weight management, stress relief, and mood enhancement (U.S. Department of Health and Human Services [USDHHS], 2008). Physical activity has also been shown to improve the overall quality of life and increase life expectancy (Jia & Lubetkin, 2014). Despite this, many youths fail to meet PA recommendations, especially African American females (USDHHS, 2008; American Heart Association [AHA], 2013). For instance, the American Heart Association (2013) reported African American adolescent girls to have the highest prevalence (26.7%) of inactivity compared to Latina (21.3%) and Caucasian (13.7%) girls. Furthermore, research exploring PA promotion amongst African American girls relied heavily on mothers' influence and excluded fathers (Ransdell et al., 2004). Given that African American women are one of the least active groups, the reliance solely on mothers may not be as influential as relying on fathers.

Resident vs Non-resident Fathers

Resident fathers live with their children while non-resident fathers live in a different household than their children. The benefits of having a resident father include lower behaviour risks, better health, greater financial stability, and greater opportunities to be involved in youth activities (Bramlett & Blumberg, 2007). In addition, children living with their fathers tend to have higher self-esteem, lower rates of obesity, and are

Received: October 18 2018 | Accepted after revision: November 1 2018 | First published online: March 01 2019

Conflict of interest: None declared.

more likely to model their father's PA habits (Trost, Kerr, & Ward, 2001). Alternatively, studies investigating non-resident fathers often highlight the disadvantages rather than potential benefits (Lucas, Nicholson, & Erbas, 2013). Favourable outcomes, however, are evident when non-resident fathers are involved, and their relationship with the other parent is healthy. For example, African American non-resident fathers have been shown to provide more caregiving to children than Caucasian counterparts (Fagan & Palkovitz, 2007; Leavell, Tamis-LeMonda, & Ruble, 2012). Given this, there is evidence to suggest that African American fathers are more involved than previous research has demonstrated.

Fathers' Involvement

The benefits of fathers' involvement in various domains of health and well-being are abundant (Alleyne-Green, et al., 2015; Ali & Dean, 2015; Coley, 2003), but research exploring benefits of fathers' involvement on PA practices among their daughters is negligible. Especially research with African American girls. Despite limited research, African American girls have reported that biological fathers positively influence their PA practices (Taylor et al., 1999). Moreover, as African American females struggle to maintain adequate amounts of PA (USDHHS, 2008), fathers may be a catalyst for increasing PA among them.

Fathers' involvement has been shown to be beneficial in other areas of health, including reducing the risk of sexual behaviours, dating violence (Alleyne-Green, et al., 2015), smoking cigarettes (Ali & Dean, 2015) and depression (Coley, 2003). Problematically, these studies only included residential fathers, which puts African American girls at a disadvantage because they are more likely to have non-resident fathers (Pew Research, 2015). Furthermore, father involvement studies commonly use quantifiable characteristics, such as time spent with children (Waller & Swisher, 2006) and financial support (Cooksey & Craig, 1998). Unfortunately, these categories, again, disadvantage African American fathers because a higher proportion of them do not reside with their children and many suffer from a lower socio-economic status (Waller & Swisher, 2006). Given this, not only is research on fathers' involvement negligible, but it also fails to take into account the cultural complexities of many African American families.

Fathers' Involvement and Physical Activity

Research has shown that fathers' involvement has a beneficial impact on boys' PA behaviours (Leavell et al., 2012; Zahra, Sebire, & Jago, 2015). The role fathers play in their sons' PA pursuits including "physical play" (Leavell et al., 2012) and higher rates of sports participation (Ellis, Caldwell, Assari, et al., 2014). Father impact may, therefore, be instrumental in boys' rates of PA as well as a slower decline of PA over their lifespan (USDHHS, 2008). Recognizing that fathers promote PA with their sons, one could argue that increased and sustained PA levels might result with daughters as well. This type of contribution is possible regardless of residence status, so PA studies exploring African American girls should consider the role of fathers. This study addresses this gap in the literature by using an inclusive approach to investigate the impact of father involvement on African American adolescent girls' PA behaviours.

It comes as no surprise that there is a positive relationship between fathers' and adolescent PA levels (Sukys et al., 2014). More specifically, the PA rates of sons and daughters directly correlated to the rates of PA of fathers (Sukys et al., 2014). Also, fathers had higher rates of PA than mothers did, and when a father had a high rate of PA, the children also had higher rates of PA (Sukys et al., 2014). This parent-child outcome was not evident in mother-child relationships (Sukys et al., 2014), posing additional challenges for African American girls. Additionally, these findings are consistent with non-African American families (Zahra, Sebire, & Jago, 2015), increasing concerns for African American girls as they are more likely to be inactive than girls of other ethnic groups (CDC, 2012; Kimm et al., 2002; USDHHS, 2008; AHA, 2013).

Fortunately, studies have shown that fathers positively influence daughters' PA behaviours. The limited studies available, however, tend to focus on children under the age of 10. For example, Krahnstoever et al.'s (2003) study of nine-year-old girls reported that parental influence, including fathers, increased girls' PA levels. Fathers also positively influenced pre-school aged children in vigorous PA (Vollmer et al., 2015). Furthermore, it has been found that "father-child time" and playing sports together also increased kindergartners' PA levels (Beets & Foley, 2008). These findings suggest that daughters may benefit from having an involved father in order to increase and sustain PA habits.

The prevalence of single-parent, female-led households for African American families (Pew Research, 2015) contributes to stereotypes that African American fathers are not involved. While there is research exploring the links between fathers' involvement and health more broadly, there is limited research on PA specifically, especially among African American families. More pointedly, to date, there has not been a single study exploring the intersection of fathers' involvement and girls PA amongst African American families. The current study aimed to determine if and how father involvement impacts PA levels among African American adolescent girls. It was hypothesized that: 1) girls reporting high levels of fathers' involvement would have higher levels of PA than girls reporting low levels of fathers' involvement, and 2) girls living with their fathers would have higher levels of PA than girls who did not reside with their fathers.

DOI 10.26773/mjssm.190304

Methods

Participants and Setting

Forty (40) self-identified African American adolescent girls aged 13 to 18 (M=16.18, SD=1.17) attending a public magnet high school in North Carolina (USA) completed surveys. The school was 66% African American, located in a predominately African American neighbourhood but attracted diverse students from around the county.

Procedures

On-site information sessions, flyers posted around the school and in-class promotion aided in recruitment. After initial contact, participants received study details, assent and parental consent packets. Arrangements made via email or phone call confirmed the location, time and date to return the required documents. Participants received reminder phone calls the evening before their appointments. Data collection occurred at the school or public locations near the participants' homes. Questionnaires took 15-20 minutes to complete, and participants received a $5 gift card to a local eatery, and free gym passes to a local fitness centre.

Variables and Measures

Fathers' involvement. Father involvement constructs were assessed using Finley and Schwartz's Father Involvement Scale (FIS) (2004), which assesses long-term retrospective accounts of father involvement designed for adolescents and young adults. Participants were asked to identify their father figure and respond to "How involved was your father (father figure) in the following aspects of your life and development? Please place the appropriate number on the line before each of the following items (domains)". The FIS includes twenty domains and three subscales (expressive, instrumental, and mentoring/advising) on fathers' involvement in children's lives using factor analysis from previous FIS research (Finley and Schwartz, 2004). Each domain has a 1 to 5-point value (e.g., 1= never involved and 5= always involved). Sum scores range from 20-100 and mean scores range from 1-5. The current study conducted an internal consistency reliability analysis using Cronbach's alpha yielding similar high scores to Finley and Schwartz (2004). A *Physical Activities* domain was added to the FIS, which used the 1 through 5 rating scale but was analysed independently. These questions explored how fathers influenced girls' PA practices.

Physical activity. PA was measured with the Godin Leisure-Time Exercise Questionnaire (GLTEQ) (Godin and Shephard, 1985). The GLTEQ assessed PA behaviours over a seven-day period and asked participants to report amounts of strenuous, moderate, and mild PA of 15 minutes or longer. An assigned metabolic equivalent value (MET) accompanied each intensity category (9, 5, and 3 respectively). Activity scores were based on total units reported under strenuous and moderate activities. Twenty-four units or more is considered active, 14-23 units are moderately active, and less than 14 units is sedentary or insufficiently active (Godin, 2011). The GLTEQ also includes the question "During a typical 7-Day period (a week), in your leisure time, how often do you engage in any regular activity long enough to work up a sweat (heart beats rapidly)?" The responses are often, sometimes, and never/rarely. Among adolescents, the GLTEQ has been shown to be reliable (Sallis et al., 1993).

Demographics. A self-created demographic questionnaire surveyed factors including age, grade, race/ethnicity, father/father-figure and family structure. In addition, if a stressful event occurred in the youth's life (e.g., divorce, death, incarceration), the survey asked at what age this occurred.

Data Analysis

The Statistical Package for the Social Sciences 15.0 (SPSS) was used for analyses. Descriptive statistics were calculated for demographic variables using a one-way analysis of variance (ANOVA) to determine group differences in the PA participation of girls who reported high versus low levels of fathers' involvement. Multiple regression analyses determined the classifications of fathers' involvement that best predicted PA.

Results

Descriptive Statistics

Forty African American girls aged 13-18 (M=16.18, SD=1.17) completed questionnaires. Twenty-four girls acknowledged biological fathers as their father figure; one acknowledged an adoptive father whom she considered biological, four identified a stepfather, five an uncle, and three a grandfather. One girl indicated that church brothers acted as father figures, one did not have a father figure and indicated that she was adopted by a single mother, and one was unable to identify a father figure. Of the 40 responses, one girl also had a father who was deceased but was active in her life prior to death. Twenty-two girls lived in single-parent households. All but one single-parent family was led by a female (20 - mother; 1- grandmother; 1- father), and 19 girls had a resident father (16 - biological fathers; 3 - stepfathers).

Physical activity. PA scores reported on the GLTEQ ranged from 0 to 83 METS with a mean score of 39.87 METS in a 7-day period, which is generally low. Fourteen (30%) participants were considered active with 24 units or more in the moderate to the strenuous category, nine (22.5%) were moderately active with 14-23 units of PA, and the majority were insufficiently active (42.5%) or in the sedentary category, with two reporting no PA.

Fathers' Involvement and Physical Activity

After combining the Sometimes (3), Often (4) and Always (5) involved father groups into the high level of father involvement category and combining the Never (0) and Rarely (1) involved father groups into the low level of father involvement category in the *PA* domain, girls reporting high levels of father involvement had higher levels of PA (M=44.39, SD=16.48, p=.055) than girls reporting low levels of father involvement (M=30.49, SD=22.5, d=.70). Additionally, girls reporting higher levels of *overall* father involvement (M=41.69, SD=23.91) had higher levels of PA than girls reporting low levels of overall father involvement (M=37.86, SD=19.08, p=.58). Both results, however, were not statistically significant. The *PA* domain had a moderately positive relationship (r=.37, p=.02); however, the regression coefficient was not statistically significant. Further, the expressive domain on the FIS, which includes "leisure, fun, play and physical development," had a correlation of r=.34, p=.03 for PA, and the mentoring and instrumental domains had the weakest correlations at r=.25, p=.12 and r=.20, p=.22, respectively. Last, girls with resident fathers also reported higher levels of PA (M=48.21, SD=27.38) than girls with non-resident fathers did (M=40.24, SD=22.11, p=.31) but the results were not statistically significant.

Responses to questions asking participants how their father/father figure influenced their PA habits complemented the quantitative findings. Twenty girls responded that their father or father figure was not instrumental in their physical activities, and twenty girls indicated that their father/father figure was instrumental in their physical activities. The responses also revealed that men other than biological fathers fulfil surrogate roles in promoting PA. Girls identified male figures including stepfathers, grandfathers, and uncles (N=14) as instrumental in their physical activities. Nine of 14 girls reported high levels of PA involvement from men other than their biological fathers.

Discussion

This study examined differences and associations between fathers' involvement and PA behaviours among African American adolescent girls. As fathers' involvement increased, levels of PA slightly increased. A similar pattern has been shown among Lithuanian adolescents (Sukys, 2014), for whom the PA levels of daughters and sons were higher when their fathers' physical activities were higher. This relationship was not evident with mothers, further supporting the need to investigate fathers' involvement and PA patterns. Additionally, the lack of research on fathers' impact and PA among adolescent girls of all ethnic groups is troublesome, since PA levels among females decline rapidly during adolescence (Kimm et al., 2002; USDHHS, 2008).

While there were relatively low rates of PA among the study sample, which is reflective of American society in general (CDC, 2012), this study suggests that fathers' involvement may improve PA of African American adolescent girls. Girls reporting high levels of fathers' involvement had higher rates of PA than girls reporting low levels of fathers' involvement, which warrants further inquiry. Studies have shown involved fathers are beneficial to the self-esteem and academic outcomes of African American girls (Cooper, 2009) and reduce the risk of getting pregnant (Peterson, 2007). Given this, a logical inference is that fathers' increased involvement may also increase PA outcomes among African American adolescent girls.

Nine of the 14 participants who identified a non-biological father-figure were among the higher PA group; therefore, biological fathers should not be the only men considered in PA interventions targeting African American adolescent girls. Studies have shown that non-biological African American fathers can be beneficial for African American families (Coley, 2003; McDougal, Durnell, & Dlamini, 2018). Coley (2003) referred to these non-biological fathers as "social fathers" and recognized the cultural complexities of many African American households by including them. She found that African American girls had more trust and lower anger towards social residential fathers than to non-residential fathers and biological fathers. This perhaps illustrates the importance of relationship quality and that non-biologically related men can contribute to the upbringing of children. Perhaps the best approach to foster PA among African American adolescent girls is to embrace the African proverb, "It Takes a Village," to include and encourage other men in the community to participate as surrogate fathers to girls and families in need.

Given the above results, there are two future areas that could be explored further: (1) relating fathers PA levels: Although the current study did not assess the PA levels of fathers, can we link fathers PA levels to girls PA levels?, and (2) Are there specific ways in which fathers are involved that are linked to girls PA levels? Lastly, from a public health standpoint, mothers should be informed of the benefits of fathers' involvement on children since they are often instrumental in fostering fathers' involvement (Fagan & Palkovitz, 2007).

Limitations

Despite the value of investigating fathers' involvement and PA among African American adolescent girls, this study's limitations included a small sample size that limits inferences and generalizations. Additionally, recall accounts used to measure PA can cause participants to over- or underreport. Furthermore, there was no objective measure (e.g., accelerometer, pedometer, heart rate monitor) of PA, and the overall activity among participants was low. Although reliable, the GLTEQ's subjectivity is a limitation inherent in recall instruments because it relies on participants' abilities to recall activity over a seven-day period; however, the reliability of the measure provided indicators (e.g., intensity and frequency of activity) to allow inferences to be made.

DOI 10.26773/mjssm.190304

The exclusion of socio-economic status and parental education was a limitation, since children from educated and affluent families tend to have higher PA levels than those from economically disadvantaged homes (CDC, 2012; Drenowatz et al., 2010). Further, parents were not asked to participate because children are often the best assessors of their fathers' involvement (Day & Lamb, 2004; Finley & Schwartz, 2004). Finally, the study excluded mothers; however, the focus on fathers was justified due to their absence in current interventions and conversations regarding daughters' PA.

Conclusion

This study identified father figure behaviours that may be instrumental in promoting the PA of African American girls. Previous studies have shown that these behaviours have been effective with sons (Zahra, Sebire, & Jago, 2015). Fathers may promote the physical activities of their daughters, similarly to sons, by increasing expectations that they be physically active, which may result in sustained PA over their lifespans. The findings of this study address a gap in the literature and act as a catalyst for further inquiry and discussion that includes the role of fathers, regardless of their biological relationship and residential status, in promoting PA among African American adolescent girls. Future research in PA that focuses on African American girls should consider the entire family dynamics, which should include the father.

REFERENCES

Alleyne-Green, B., Grinnell-Davis, C., Clark, T. T., & Cryer-Coupet, Q. R. (2015). The role of fathers in reducing dating violence victimization and sexual risk behaviors among a national sample of Black adolescents. *Children and Youth Services Review, 55*, 48-55. doi:10.1016/j.childyouth.2015.04.005

American Heart Association. Statistical Fact Sheet 2013 Update. (2013). *Physical Inactivity* Retrieved from https://www.heart.org/idc/groups/heartpublic/@wcm/@sop/@smd/documents/downloadable/ucm_319589.pdf

Barr-Anderson, D.J., Adams-Wynn, A.W., Alhassan, S., et al. (2014). Culturally-appropriate, family- and community- based physical activity and healthy eating intervention for African-American middle school-aged girls: A feasibility pilot. *Journal of Adolescent and Family Health* 6(2): Article 6.

Beets, M. W., & Foley, J. T. (2008). Association of Father Involvement and Neighborhood Quality with Kindergartners' Physical Activity: A Multilevel Structural Equation Model. *American Journal of Health Promotion, 22*(3), 195-203.

Bramlett, M.D., & Blumber, S.J. (2007). Family structure and children's physical and mental health. *Health Affair, 26*(2): 549-558.

Centers for Disease Control and Prevention (2012). *Division of nutrition, physical activity, and obesity.* Retrieved from www.cdc.gov/nccdphp/dnpao/index.html (accessed date is unknown).

Coley, R. L. (2003). Daughter-father relationships and adolescent psychosocial functioning in low-income African American families. *Journal of Marriage and Family, 65,* 867-875.

Cooksey, E.C., & Craig, P.H. (1998). Parenting from a distance: The effects of paternal characteristics on contact between nonresidential fathers and their children. *Demography* 35(2): 187-200.

Cooper, S.M. (2009). Associations between father-daughter relationship quality and the academic engagement of African American adolescent girls: Self-esteem as a mediator? *Journal of Black Psychology*, *35*(4): 495-516.

Day, R., & Lamb, M. (2004). *Conceptualizing and Measuring Father Involvement.* Mahwah, NJ: Routledge.

Davison, K. K., Cutting, T. M., & Birch, L. L. (2003). Parents' activity-related parenting practices predict girls' physical activity. *Medicine & Science in Sports & Exercise, 35*(9), 1589-1595. doi:10.1249/01.MSS.0000084524.19408.0C

Drenowatz, C., Eisenmann, J.C., Pfeiffer, K.A., et al. (2010). Influence of socio-economic status on habitual physical activity and sedentary behavior in 8- to 11-year old children. *BMC Public Health*, *10,* 214.

Ellis, K.R., Caldwell, C.H., Assari, S., et al. (2014). Nonresident African American fathers' influence on sons' exercise intentions in the fathers and sons program. *The Science of Lifestyle Change*, *29*(2): 89-98.

Fagan, J., & Palkovitz, R. (2007). Unmarried, nonresident fathers' involvement with their infants: A risk and resilience perspective. *Journal of Family Psychology*, *21*(3): 479-489.

Finley, G.E., & Schwartz, S.J. (2004). The father involvement and nurturant fathering scales: Retrospective measures for adolescent and adult children. *Educational and Psychological Measurement*, *64*(1): 143-164.

Godin, G., & Shephard, R.J. (1985). A simple method to assess exercise behavior in the community. *Canadian Journal of Applied Sport Sciences, 10*, 141-146.

Jia, H., & Lubetikin, E.I. (2014). Comparing quality-adjusted life expectancy at different levels of physical activity. *Journal of Physical Activity and Health, 11*, 278-284.

Kimm, S., Glynn, N., Kriska, A., et al. (2002). Decline in physical activity in African American girls and white girls during adolescence. *The New England Journal of Medicine, 347*(10): 709-715.

Leavell, A., Tamis-LeMonda, C., Ruble, D., Zosuls, K., & Cabrera, N. (2012). African American, White and Latino Fathers' Activities with their Sons and Daughters in Early Childhood. *Sex Roles, 66*(1-2), 53-65. doi:10.1007/s11199-011-0080-8

Lucas, N., Nicholson, J.M., & Erbas, B. (2013). Child mental health after parental separation: The impact of

resident/non-resident parenting, parent mental health, conflict and socioeconomics. *Journal of Family Studies, 19*(1): 53-69.

McDougal, I. I. I. S., Durnell, E., & Dlamini, P. Z. (2018). Social father presence: The experience of being raised by Black social fathers. *Journal of Pan African Studies, 11*(6), 1-23.

Peterson, S.H. (2007). The importance of fathers: Contextualizing sexual risk-taking in "low-risk" African American adolescent girls. *Journal of Human Behavior in the Social Environment, 15*, (2/3), 329-346.

Pew Research Center (2015). Parenting in America: Outlook, worries, aspirations are strongly linked to financial situation. Available at: www.pewsocialtrends.org/2015/12/17/1-the-american-family-today/ Retrieved July 17, 2017.

Ransdell, L.B., Delting, N.J., Taylor, A., & Reel, J., Barry, S. (2004). Effects of home- and university based programs on physical self-perception in mothers and daughters. *Women and Health, 39*(2): 63-81.

Raudsepp, L, & Viira, R. (2000). Influence of parents' and siblings' physical activity on activity levels of adolescents. *European Journal of Physical Education, 5*, 169-178.

Sallis, J. F., Haskell, W. L., & Wood, P. D., Fortmann, S. P., Rogers, T., Blair, S. N, & Paffenbarger, R. (1985). Physical activity assessment methodology in the Five-City Project. *American Journal of Epidemiology,* 121(1), 91-106.

Sukys, S., Majauskiene, D., Cesnaitiene, V.J., et al. (2014). Do parents' exercise habits predict 13-18-year-old adolescents' involvement in sport? *Journal of Sports Science and Medicine, 13*, 522-528.

United States Department of Health and Human Services/Center for Disease Control and Prevention. (2008). *Physical Activity Guidelines for America*, Retrieved from https://health.gov/paguidelines/guidelines/

Waller, M.R., & Swisher, R. (2006). Fathers' risk factors in fragile families: Implications for "healthy" relationships and father involvement. *Social Problems, 53*(3): 392-420.

Zahra, J., Sebire, S.J., & Jago, R. (2015). "He's probably more Mr. Sport than me": A qualitative exploration of mothers' perceptions of fathers' role in their children's physical activity. *BMC Pediatrics* 15(1): 1-9.

DOI 10.26773/mjssm.190304

ORIGINAL SCIENTIFIC PAPER

The Influence of Coaches' Instruction on Technical Actions, Tactical Behaviour, and External Workload in Football Small-Sided Games

Jorge Batista[1,2,3], Bruno Goncalves[2,4], Jaime Sampaio[2,4], Julia Castro[1,2], Eduardo Abade[1,2], Bruno Travassos[2,3]

Affiliations: [1]University Institute of Maia, Department of Physical Education and Sports Sciences (ISMAI), Maia, Portugal, [2]Research Centre in Sports Sciences, Health Sciences and Human Development (CIDESD), Vila Real, Portugal, [3]Universidade da Beira Interior, Department of Sport Sciences, Covilhã, Portugal, [4]Universidade de Trás-os-Montes e Alto Douro, Department of Sport Sciences, Exercise and Health, Vila Real, Portugal

Correspondence: B. Travassos, Universidade da Beira Interior, Sport Sciences Department, Convento de Sto António, 62001-001 Covilhã, Portugal. E-mail: bruno.travassos@ubi.pt

ABSTRACT This study aimed to explore the effects of previous instruction on technical, tactical and external workload performances in football small-sided games. Two 7-a-side balanced competitive teams received instructions regarding the rules of the small-sided games proposed. Additionally, one team received instructions from the coach regarding the collective tactical behaviour required for each exercise condition: (a) Without strategic instruction (WSI); (b) Defensive strategy (DS); (c) Offensive strategy (OS) to play against the team that only received the rules of the small-sided games. The comparisons among game scenarios were assessed via standardised mean differences. The comparison between WSI and DS revealed higher number of defensive actions, less space covered, and more distance covered in jogging for DS in comparison with WSI. The comparison between WSI and OS revealed more passes per ball possession, larger team length, larger space covered, lower distance covered walking, and more distance covered in jogging for OS in comparison with WSI. The results reinforce that coaches' previous instruction constrains the technical, tactical, and physical demands of small-sided games in football. The use of previous instruction regarding strategical and tactical behaviour allows highlighting the players' behaviour and ensures functional team performance.

KEY WORDS practice tasks, coaches' intervention; constraints, team sports, collective behaviour

@MJSSMontenegro
COACHES' INSTRUCTION IN FOOTBALL SMALL-SIDED GAMES
http://mjssm.me/?sekcija=article&artid=170

Introduction

The ability of team sports' coaches to manage task constraints in training practices is paramount to develop players and teams' performance (Potrac, Brewer, Jones, Armour, & Hoff, 2000). Under this scope, some intervention models have been proposed in the literature in an attempt to identify the key knowledge and competences of successful sport coaches (Cushion, Armour, & Jones, 2006). Among the different skills that a coach uses, the ability to communicate with players and to focus their attention on tasks is a key issue (Potrac et al., 2000) For instance, the correct design of practice tasks or the correct use of verbal instruction are fundamental skills for the development of physical, technical, and tactical skills (Aguiar, Botelho, Gonçalves, & Sampaio, 2013; Travassos, Duarte, Vilar, Davids, & Araújo, 2012; Williams & Hodges, 2005).

Taking into consideration the constraint-lead approach, the coaches' ability to manipulate and intervene in training contexts according to specific competitions scenarios increases players' attentional focus and promotes the transference of behaviours between training and competition (Renshaw, Davids, Shuttleworth, &

Received: September 03 2018 | Accepted after revision: November 01 2018 | First published online: March 01 2019

Conflict of interest: None declared.

Chow, 2009). Over the years, studies have been focused on the manipulation of rules in order to investigate its effects on technical, tactical and physical performance (Aguiar et al., 2013; Hill-Haas, Dawson, Impellizzeri, & Coutts, 2011; Olthof, Frencken, & Lemmink, 2017; Vilar et al., 2014). Such strategies, commonly used in small-sided games (SSG) contexts (i.e., manipulation of space, number of players, number of goals, corridors…) aims to trigger the emergence of individual behaviours that lead to functional team behaviours (Côté & Gilbert, 2009; Davids, Araújo, Correia, & Vilar, 2013).

Additionally, over the last years, some studies have analysed the effect of changes on instruction in the learning process of players and physical education students (Cordovil, Araujo, Davids, & Gouveia, 2009; García, Sabido, Barbado, & Moreno, 2013; Práxedes, Moreno, Sevil, García-González, & Del Villar, 2016). Cordovil et al. (2009) showed that the manipulation of initial instruction in basketball (neutral, risk or conservative) promoted changes in interpersonal relationships among players and affected the way players explored space during 1x1 basketball tasks. García et al. (2013) studied the effects of instruction on the velocity and precision of handball shots in players of different levels and showed that instruction was most effective for less experienced players than for experienced ones. Also, Práxedes et al. (2016) recently suggested that the use of questioning in the practice of SSG allow the improvement of individual actions of players, such as the pass and the dribble.

In practice, the initial instruction is frequently used to manipulate training tasks according to the task goals and the expected offensive and defensive behaviour of teams (Cushion et al., 2006). In fact, initial instruction is one of the constraints most used by coaches when describing and defining the exercise aim and reinforcing the main possibilities of play. For that, task manipulation and initial instruction should be aligned with the strategic ideas of the coach to promote the transfer of team behaviours from training tasks to the competitive game environment (Renshaw et al., 2009). However, most of the time, coaches' perceptions did not match the obtained effects, and scientific knowledge is scarce regarding its effects on practice (Millar, Oldham, & Donovan, 2011). To the best of our knowledge, no studies have been developed in football with the goal of understanding the effect of the initial instruction on the technical, tactical, and physical performance of players and teams.

Thus, the aim of this study was to assess the effects of coaches' strategic instruction on defensive and offensive performance in football small-sided games. Changes in technical actions, tactical behaviour, and external workload between teams that did not receive any strategic instruction, or received strategic instructions related to defensive or offensive behaviours were expected.

Methods

Participants

Sixteen semi-professional football players participated in the study (age: 23.9±5.4 years old, body mass: 72.4±6 kg, height: 1.79±0.6 m and playing experience: 11.2±5.3 years). All players were part of the same club. The participants and coaching staff agreed with the protocol description and were notified that they could withdraw from the study at any time. Written informed consent was obtained from all participants. The investigation was approved by the local Institutional Research Ethics Committee and conformed to the recommendations of the 1964 Declaration of Helsinki.

Procedures

A cross-sectional field study was used to identify the effects of instructions in the technical, tactical, and physical behaviour of players and teams in small-sided games. Before the experimental session, there was a 15-min standardised warm-up based on running, ball possession, and dynamic stretching exercises. The outfield players were divided into two 7-a-side balanced competitive teams. Both teams received instructions regarding the rules of the small-sided games proposed.

Additionally, one team received instructions from the coach regarding the individual and collective tactical behaviour required for each exercise condition: (a) without strategic instruction (WSI); (b) Defensive strategy (DS); (c) Offensive strategy (OS). In the first exercise (WSI), both teams only received instructions regarding the rules of the small-sided game. In the second exercise (DS), one team was instructed to maintain the team compactness in the inner zones of the field in order to regain ball possession and explore counter-attacks to win the game. In the third exercise (OS), the instructed team was required to maintain ball possession and to only attack when a clear advantage was created. During the instruction, the coach highlighted the partial goals of the team and the distribution of players on the space that the team should promote to ensure the achievement of the proposed goals.

Each team played against the opponent twice in a randomised sequence in two different days (day 1: OS, WSI, DS and day 2: WSI, DS, OS), and data from outfield players were analysed comparing the performance of each team in each exercise. The two goalkeepers (GK) also participated in the protocol but were excluded from the data analysis. The 7-a-side games for testing the effects of instructions lasted for five minutes interspersed with three minutes of passive recovery and were played on a 62 × 50 metres in natural grass pitch, respecting the official football rules.

DOI 10.26773/mjssm.190305

Data collection

The technical actions of the players during the small-sided games that characterise defensive or attacking purposes were registered using a notational analysis system. The games were recorded using a video camera (CANON Legria HF G40) and the number of passes per ball possession (PBP) and the number of ball recoveries in inner zones (BR) were registered.

The dynamic players' positioning was gathered using a non-differential 5Hz GPS system and used to compute both tactical and external workload variables. Tactical behaviour was analysed based on teams' length, teams' width, and teams' effective playing space (EPS) (computed using convex hull). The external workload was assessed through total distance covered by players and distance covered at different movement speed categories (Folgado, Duarte, Fernandes, & Sampaio, 2014): 0.0-3.5 km/h (walking); 3.6-14.3 km/h (jogging); 14.4-19.7 km/h (running); and >19.8 km/h (sprinting). All the variables were computed using dedicated routines in Matlab® software (MathWorks, Inc., Massachusetts, USA).

Statistical Analysis

Magnitude-based inferences and the precision of estimation were used to avoid the shortcomings of research approaches supported by the null-hypothesis significance testing (Batterham & Hopkins, 2006). Prior to the game comparisons, all processed variables were log-transformed to reduce the non-uniformity of error. A descriptive analysis was performed using mean and standard deviations for each variable. The comparisons among game scenarios were assessed via standardised mean differences, computed with pooled variance and respective 90% confidence intervals (Cumming, 2012; Hopkins, Marshall, Batterham, & Hanin, 2009). Thresholds for effect sizes statistics were 0.2, trivial; 0.6, small; 1.2, moderate; 2.0, large; and >2.0, very large (Hopkins et al., 2009). Differences in means for both pairs of scenarios were also expressed and graphically represented in percentage units with 90% confidence limits (CL). The effect was reported as unclear if the CL overlapped the thresholds for the smallest worthwhile changes, which were computed from the standardised units multiplied by 0.2. Magnitudes of clear effects were described probabilistically according to the following scale: 25-75%, possible; 75-95%, likely; 95-99%, very likely; >99%, most likely (Hopkins et al., 2009).

Results

As expected, the comparison between free game scenarios in competition revealed unclear effects on technical, tactical behaviour, and external workload.

The analysis of technical actions revealed the most likely large higher ball recoveries in inner zones for DS in comparison with WSI. Furthermore, likely moderate higher PBP for OS in comparison with WSI was observed. The other technical actions revealed unclear effects for the comparison between all the game scenarios (see Table 1 and Figure 1).

TABLE 1 Descriptive results from the comparisons among considered game scenarios for technical variables

Technical actions	Game (mean±SD)		
	WSI vs WSI	WSI vs DS	WSI vs OS
Ball recoveries in inner zones	2.3±2.1 vs 3.3±1.9	2.0±0.8 vs 6.3±3.1	1.3±0.4 vs 2.0±0.8
Nº passes per ball possession	3.9±1.8 vs 5.1±3.17	3.9±2.2 vs 3.3±1.2	3.6±1.8 vs 6.1±2.2

Note. WSI - without strategic instruction; DS - defensive strategy; OS - offensive strategy.

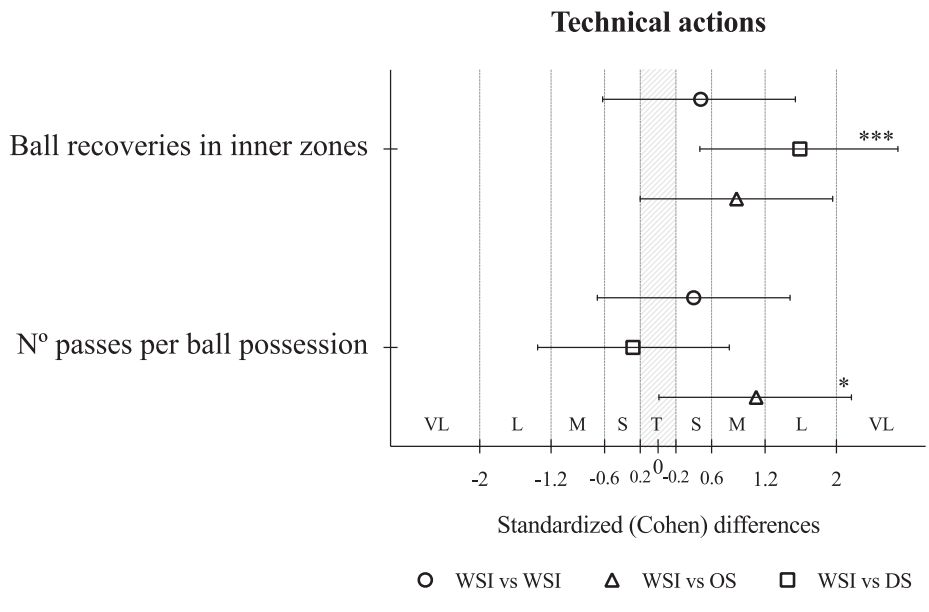


FIGURE 1 Standardized (Cohen) differences in technical variables according to the game scenarios' comparisons. Error bars indicate uncertainty in the true mean changes with 90% confidence intervals. Asterisks indicate the likelihood for the magnitude of the true differences in mean as follows: *likely; ***most likely

The analysis of tactical actions revealed likely moderate lower EPS for DS in comparison with WSI. Furthermore, very likely large higher team length and likely moderate higher EPS for OS in comparison with WSI were observed. The other tactical actions revealed unclear effects for the comparison between all the game scenarios (see Table 2 and Figure 2).

TABLE 2 Descriptive results from the comparisons among considered game scenarios for tactical variables

Tactical behaviour	Game (mean±SD)		
	WSI vs WSI	WSI vs DS	WSI vs OS
Team Length (m)	20.2±4.1 vs 20.7±2.1	17.2±1.1 vs 16.8±1.2	18.2±2.4 vs 21.2±1.7
Team Width (m)	32.6±4.7 vs 33.8±2.4	31.6±3.3 vs 30.6±4.8	29.6±2.4 vs 31.3±3.4
Effective playing space (m^2)	398.1±79.3vs 403.2±46.2	344.6±24.7 vs 304.6±47.1	318.4±55.6 vs 382.9±57.7

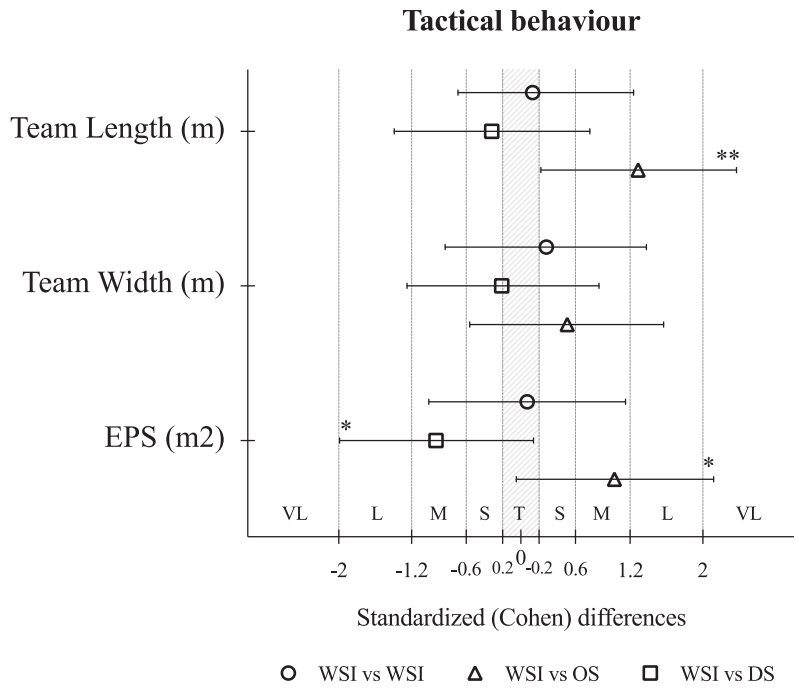


FIGURE 2 Standardized (Cohen) differences in tactical variables according to the game scenarios' comparisons. Error bars indicate uncertainty in the true mean changes with 90% confidence intervals. EPS = effective playing space. Asterisks indicate the likelihood for the magnitude of the true differences in mean as follows: *likely; **very likely

The analysis of external workload revealed likely moderate higher distance covered in jogging for DS in comparison with WSI. Furthermore, likely moderate higher total distance covered, likely moderate lower distance covered walking, and most likely large higher distance covered jogging for OS in comparison with WSI were revealed. The other external load variables revealed unclear effects for the comparison between all the game scenarios (see Table 3 and Figure 3).

TABLE 3 Descriptive results from the comparisons among considered game scenarios for external load variables

External workload	Game (mean±SD)		
	WSI vs WSI	WSI vs DS	WSI vs OS
Total distance covered (m)	636.4±40.3 vs 607.1±37.9	567.9±42.2 vs 591.1±60.9	558.3±75.1 vs 630.1±60.4
Dist covered Walking (0 - 3.5 km/h)	33.5±5.9 vs 34.4±5.8	48.5±9.4 vs 37.4±13.2	49.3±14.3 vs 34.8±11.6
Dist covered Jogging (3.6 - 14.3 km/h)	487.3±31.4 vs 470.1±36.1	412.4±34.8 vs 467.3±59.5	404.5±61.7 vs 489.4±46.5
Dist covered Running (14.4 - 19.7 km/h)	96.3±20.7 vs 75.4±38.7	83.5±32.9 vs 69.6±9.7	78.6±21.4 vs 82.6±37.4
Dist covered Sprinting (> 19.8 km/h)	19.6±16.5 vs 18.1±15.8	23.4±10.8 vs 16.6±14.1	26.1±24.7 vs 23.6±14.9

DOI 10.26773/mjssm.190305

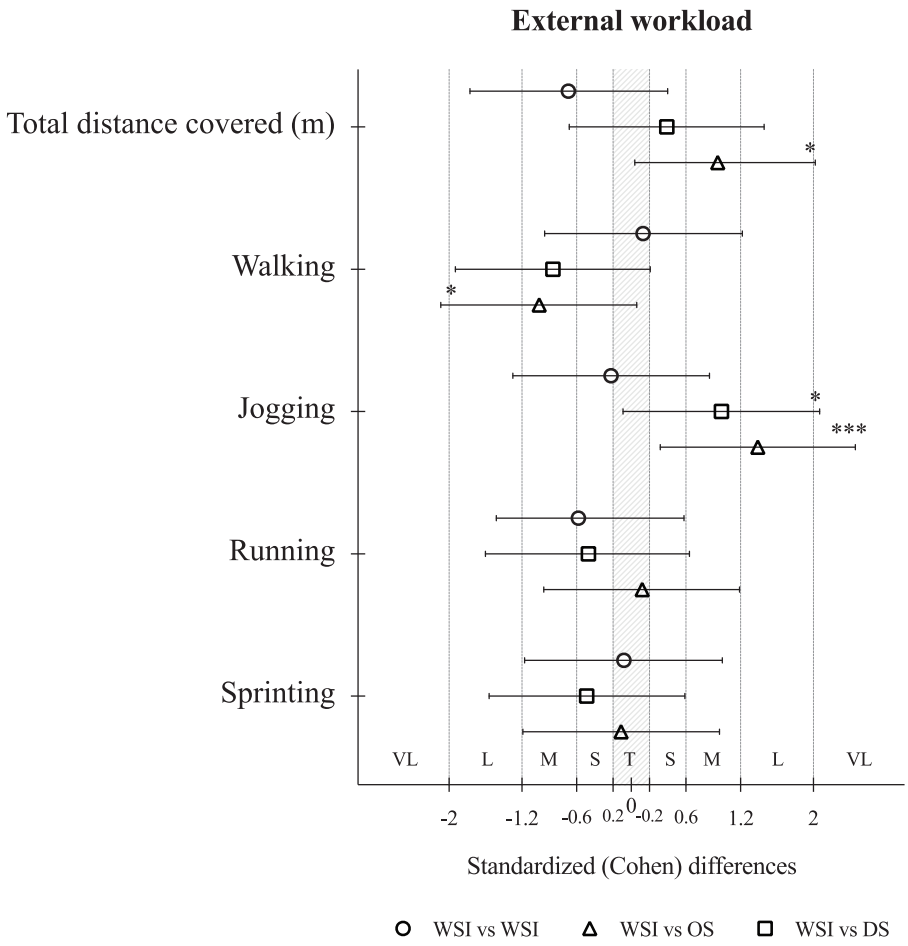


FIGURE 3 Standardized (Cohen) differences in external workload variables according to the game scenarios' comparisons. Error bars indicate uncertainty in the true mean changes with 90% confidence intervals. Asterisks indicate the likelihood for the magnitude of the true differences in mean as follows: *likely; ***most likely

Discussion

This study aimed to investigate the effects of changes on coaches' strategic instruction in technical actions, tactical behaviour, and external workload during football small-sided games.

Overall, the results showed that teams in which only WSI was used for both teams, the training tasks did not change technical, tactical and external load performances. The results confirmed that the use of coaches' strategic defensive and offensive instructions (i.e., DS and OS) constrains the technical, tactical, and physical performance of players and teams (Cushion et al., 2006; Millar et al., 2011). Regarding the team that received DS instructions, it was observed that they recovered more ball possessions in final pitch areas, decreased the space occupied, and increased the distance covered in jogging. Finally, the team that received OS instructions increased the number of passes and increased the space occupied in the pitch compared to the team that did not receive instruction. Surprisingly, this team increased the distance covered in jogging in comparison to the team WSI. These results highlight that the team that did not receive initial instruction explored individual and collective possibilities for action only based on situational information and without considering the strategic collective behaviour of the team (Renshaw et al., 2009). The definition of the strategic defensive or offensive behaviour allows that teams to direct the attention to taskwork with implicit coordination related with the goals previously defined in comparison with the team that did not receive such information (Eccles & Tenenbaum, 2004).

Defensively, results suggest that after receiving DS instruction, teams perform more compactly throughout the game. The use of strategic instruction (e.g., maintain the team compactness in the inner zones of the pitch, in order to recover ball possession and explore counter-attacks) constraint the way that players perceive their own and teammates actions in order to potentiate their collective defensive behaviour (Silva, Garganta, Araujo, Davids, & Aguiar, 2013). In defensive terms, the DS instruction also constrains the team only to try to recover ball possession in more favourable zones. Interestingly, results show that individual adjustments performed to achieve an optimal collective defensive behaviour have an impact on the external load, particularly on the jogging distance. These results are in line with previous investigations that show that when

defensive behaviours are emphasised, players tend to compact the game space making their positioning more regular among teammates (Travassos, Gonçalves, Marcelino, Monteiro, & Sampaio, 2014; Vilar et al., 2014). Thus, the initial verbal instruction focused on DS behaviours of the team can promote changes in the external load indexes of the exercises. Similar results were found through the handling of information about game and exercise time with impact on pacing (Ferraz et al., 2018) and on spatial-temporal relations between teams (Gonçalves et al., 2017).

With respect to instruction focused on OS, the results promote the use of a greater EPS, greater depth, as well as a greater number of passes per ball possession in comparison to the team without prior information. When defining that the OS of the team was to maintain ball possession and to attack the goal only when there was an advantage to creating a successful finalisation scenario, coach promoted a more supported game in a greater playing space. Inclusively, the greater depth of the team may be linked to more space between defensive lines and consequently the existence of more evident passing lines to progress in the field (Sgrò, Aiello, Casella, & Lipoma, 2016).

As previously mentioned, highlighting the collective possibilities of play may promote the emergence of individual adaptations to collective demands. This emergent behaviour arises through the existence of shared affordances supported by existing contextual information and based on the intentionality of individual players to exploit the collective goal (Silva et al., 2013). The capacity of coaches to focus the attention of players on the spatial-temporal relations that support successful actions is key for this process (Cushion et al., 2006; Millar et al., 2011; Silva et al., 2013). In this case, it is possible to consider that the information provided by the coaches' previous instruction clearly constrain the exploration of the players' collective behaviour. However, this may not be valid for players and/or teams with different levels of skill or playing experience (Pritchard, Hawkins, Wiegand, & Metzler, 2008).

As previously noted the external load of the team with previous instruction focused on OS was lower in walking but increased in jogging. To keep ball possession, the attackers are required to perform constant supportive movements to the ball carrier, which enhances collectively external load in jogging. Thus, it means that external load is strongly linked to the team's tactical aims and this should be considered when selecting instructions and task constraints (Hill-Haas et al., 2011; Owen et al., 2016; Sampaio, Lago, Gonçalves, Maçãs, & Leite, 2013). These results reinforce the idea that the game pace of the team is determined by the collective goals of the team, with players adjusting the speed and precision of the collective actions to manage the playing space and to identify functional possibilities for action (Folgado, Duarte, Marques, & Sampaio, 2015).

In summary, the coaches' instruction should be focused on the objective of the actions in order to promote individual and collective adaptations (Williams & Hodges, 2005). The definition and manipulation of the defensive and offensive objectives linked to the initial instruction have a huge effect on the players and teams' performance and on the transfer of such behaviours to the competitive environment.

Nevertheless, it should be noted that the experimental design of this study presents some limitations that do not allow its generalisation to all contexts. It is not possible to measure the players' level of knowledge and the level of detail that each team needs to promote functional adaptations in their behaviour (García et al., 2013). The outcomes of this work must be considered and interpreted by each coach at the time of the definition of the previous instruction. Future investigations should consider larger samples, including more teams from different levels.

Conclusion

In conclusion, the present study revealed that coaches' instruction at the beginning of the practice tasks, constrains the technical, tactical, and physical demands of small-sided games in football. The use of strategic instruction allows highlighting the shared affordances that support the collective behaviour of teams to perform functionally. Thus, the use of appropriate coaches' instruction at the beginning of practice tasks could be paramount to focusing players on the key informational constraints that will support their individual and, consequently, collective solutions throughout the game. More than the definition of the moves required, coaches should highlight the goals that should be explored over the practice sessions to help players to discover and explore more functional technical and tactical solutions. The expected external load of each practice task should be aligned with the practice task manipulations and instructions to promote the right preparedness of players.

REFERENCES

Aguiar, M., Botelho, G., Gonçalves, B., & Sampaio, J. (2013). Physiological responses and activity profiles of football small-sided games. *Journal of Strength and Conditioning Research, 27*(5), 1287-1294. doi:10.1519/JSC.0b013e318267a35c

Batterham, A. M., & Hopkins, W. G. (2006). Making Meaningful Inferences About Magnitudes. *International Journal of Sports Physiology and Performance, 1*(1), 50-57.

Cordovil, R., Araujo, D., Davids, K., & Gouveia, L. (2009). The influence of instructions and body-scaling as constraints on decision-making processes in team sports. *European journal of sport science, 9*(3), 169-179.

DOI 10.26773/mjssm.190305

doi:10.1080/17461390902763417
Côté, J., & Gilbert, W. (2009). An integrative definition of coaching effectiveness and expertise. *International journal of sports science & coaching, 4*(3), 307-323.
Cumming, G. (2012). *Understanding the New Statistics: Effect Sizes, Confidence Intervals, and Meta-Analysis*. New York: Routledge, Taylor & Francis Group.
Cushion, C. J., Armour, K. M., & Jones, R. L. (2006). Locating the coaching process in practice: models 'for'and 'of'coaching. *Physical education and sport pedagogy, 11*(01), 83-99.
Davids, K., Araújo, D., Correia, V., & Vilar, L. (2013). How small-sided and conditioned games enhance acquisition of movement and decision-making skills. *Exercise and sport sciences reviews, 41*(3), 154-161.
Eccles, D., & Tenenbaum, G. (2004). Why an expert team is more than a team of experts: a social-cognitive conceptualization of team coordination and communication in sport. *Journal of sport & exercise psychology, 26*(4), 542-560.
Ferraz, R., Gonçalves, B., Coutinho, D., Marinho, D. A., Sampaio, J., & Marques, M. C. (2018). Pacing behaviour of players in team sports: Influence of match status manipulation and task duration knowledge. *PLoS ONE, 13*(2), e0192399. doi:10.1371/journal.pone.0192399
Folgado, H., Duarte, R., Fernandes, O., & Sampaio, J. (2014). Competing with Lower Level Opponents Decreases Intra-Team Movement Synchronization and Time-Motion Demands during Pre-Season Soccer Matches. *PLoS ONE, 9*(5), e97145. doi:10.1371/journal.pone.0097145
Folgado, H., Duarte, R., Marques, P., & Sampaio, J. (2015). The effects of congested fixtures period on tactical and physical performance in elite football. *Journal of Sports Sciences, 33*(12), 1238-1247. doi:10.1080/02640414.2015.1022576
García, J. A., Sabido, R., Barbado, D., & Moreno, F. J. (2013). Analysis of the relation between throwing speed and throwing accuracy in team-handball according to instruction. *European journal of sport science, 13*(2), 149-154.
Gonçalves, B., Esteves, P., Folgado, H., Ric, A., Torrents, C., & Sampaio, J. (2017). Effects of Pitch Area-Restrictions on Tactical Behavior, Physical, and Physiological Performances in Soccer Large-Sided Games. *Journal of Strength and Conditioning Research, 31*(9), 2398-2408. doi:10.1519/JSC.0000000000001700
Hill-Haas, S., Dawson, B., Impellizzeri, M., & Coutts, J. (2011). Physiology of Small-Sided Games Training in Football: A Systematic Review. *Sports Medicine, 41*(3), 199-220. doi:0112-1642/11/0003-0199
Hopkins, W. G., Marshall, S. W., Batterham, A. M., & Hanin, J. (2009). Progressive Statistics for Studies in Sports Medicine and Exercise Science. *Medicine and Science in Sports and Exercise, 41*(1), 3-12. doi:Doi 10.1249/Mss.0b013e31818cb278
Millar, S.-K., Oldham, A. R. H., & Donovan, M. (2011). Coaches' Self-Awareness of Timing, Nature and Intent of Verbal Instructions to Athletes. *International journal of sports science & coaching, 6*(4), 503-513. doi:10.1260/1747-9541.6.4.503
Olthof, S. B., Frencken, W. G., & Lemmink, K. A. (2017). Match-derived relative pitch area changes the physical and team tactical performance of elite soccer players in small-sided soccer games. *Journal of Sports Sciences*, 1-7.
Owen, A. L., Dunlop, G., Rouissi, M., Haddad, M., Mendes, B., & Chamari, K. (2016). Analysis of positional training loads (ratings of perceived exertion) during various-sided games in European professional soccer players. *International journal of sports science & coaching, 11*(3), 374-381.
Potrac, P., Brewer, C., Jones, R., Armour, K., & Hoff, J. (2000). Toward an Holistic Understanding of the Coaching Process. *Quest, 52*(2), 186-199. doi:10.1080/00336297.2000.10491709
Práxedes, A., Moreno, A., Sevil, J., García-González, L., & Del Villar, F. (2016). A preliminary study of the effects of a comprehensive teaching program, based on questioning, to improve tactical actions in young footballers. *Perceptual and Motor Skills, 122*(3), 742-756.
Pritchard, T., Hawkins, A., Wiegand, R., & Metzler, J. N. (2008). Effects of Two Instructional Approaches on Skill Development, Knowledge, and Game Performance. *Measurement in Physical Education and Exercise Science, 12*(4), 219-236. doi:10.1080/10913670802349774
Renshaw, I., Davids, K., Shuttleworth, R., & Chow, J. Y. (2009). Insights from ecological psychology and dynamical systems theory can underpin a philosophy of coaching. *International Journal of Sport Pshychology, 40*, 580–602.
Sampaio, J., Lago, C., Gonçalves, B., Maçãs, V., & Leite, N. (2013). Effects of pacing, status and unbalance in time motion variables, heart rate and tactical behaviour when playing 5-a-side football small-sided games. *Journal of Science and Medicine in Sport, 17*(2), 229-233.
Sgrò, F., Aiello, F., Casella, A., & Lipoma, M. (2016). Offensive strategies in the European Football Championship 2012. *Perceptual and motor skills, 123*(3), 792-809.
Silva, P., Garganta, J., Araujo, D., Davids, K., & Aguiar, P. (2013). Shared knowledge or shared affordances? Insights from an ecological dynamics approach to team coordination in sports. *Sports Medicine, 43*(9), 765-772. doi:10.1007/s40279-013-0070-9
Travassos, B., Duarte, R., Vilar, L., Davids, K., & Araújo, D. (2012). Practice task design in team sports: Representativeness enhanced by increasing opportunities for action. *Journal of Sports Sciences, 30*(13), 1447-1454. doi:10.1080/02640414.2012.712716
Travassos, B., Gonçalves, B., Marcelino, R., Monteiro, R., & Sampaio, J. (2014). How perceiving additional targets modifies teams' tactical behavior during football small-sided games. *Human movement science,*

38, 241-250.
Vilar, L., Esteves, P., Travassos, B., Passos, P., Lago-Peñas, C., & Davids, K. (2014). Varying Numbers of Players in Small-Sided Soccer Games Modifies Action Opportunities During Training. *International Journal of Sports Science and Coaching, 9*(5), 1007-1018.
Williams, A. M., & Hodges, N. J. (2005). Practice, instruction and skill acquisition in soccer: Challenging tradition. *Journal of Sports Sciences, 23*(6), 637 - 650. doi:10.1080/02640410400021328

.

DOI 10.26773/mjssm.190305

ORIGINAL SCIENTIFIC PAPER

Neuromuscular Adaptations after Blood Flow Restriction Training Combined with Nutritional Supplementation: A Preliminary Study

Ivan Chulvi-Medrano[1], Moises Picon-Martinez[1], Miguel Garcia-Jaen[1], Juan Manuel Cortell-Tormo[1], Yasser Alakhdar[2], Gilberto Laurentino[3]

Affiliations: [1]University of Alicante, Faculty of Education, Department of General and Specific Didactics, Alicante, Spain, [2]University of Valencia. Faculty of Physiotherapy, Valencia, Spain, [3]University of Sao Paulo, Department of Biodynamics of the Human Body Movement, Sao Paulo, Brasil

Correspondence: J. M. Cortell-Tormo, University of Alicante, Faculty of Education, Department of General and Specific Didactics, 03960 - San Vicente del Raspeig s/n, Alicante, Spain. E-mail: jm.cortell@ua.es

ABSTRACT Blood flow restriction training (BFRT) has been shown to be an effective alternative technique to conventional resistance training to increase skeletal muscle hypertrophy and strength. However, neuromuscular response to BFRT in combination with nutritional supplementation has rarely been studied. The purpose of this study was to investigate the effects of BFRT combined with creatine monohydrate (CrM) and/or hydroxymethyl butyrate (HMB) on skeletal muscle size and strength. Fifteen healthy males were randomly divided into three groups: a) BFRT without supplementation (C-BFR); b) BFRT with CrM supplementation (0.3 g / kg^{-1}) (CrM-BFR); and c) BFRT with CrM (0.3 g / kg^{-1}) and HMB (3 g) supplementation (CrM + HMB-BFR). Participants performed elbow flexion exercise (30% of maximal isometric voluntary contraction (MIVC)) at 30% of total occlusion pressure, twice a week, for three weeks. MIVC of the elbow flexion and brachial biceps muscle thickness were assessed pre- and post-training. There was no significant group-by-time interaction for MIVC values ($p>0.05$). Biceps muscle thickness was significantly increased from pre- to post-test in all groups ($p<0.05$). The C-BFR group obtained a greater value of effect size ($d=2.2$). These findings suggest that 3 weeks of CrM and HMB supplementation had no influence on BFRT-induced neuromuscular adaptations.

KEY WORDS Skeletal muscle hypertrophy, muscle strength, occlusion training.

@MJSSMontenegro
BLOOD FLOW RESTRICTION TRAINING
http://mjssm.me/?sekcija=article&artid=171

Introduction

Resistance training (RT) is essential to promoting neuromuscular adaptations in a large range of the population. Consequently, the American College of Sports Medicine (ACSM) guidelines recommend using loads of ≥70% of one repetition maximum (1RM) to achieve muscular hypertrophy and strength gains (American College of Sports Medicine, 2009). While these guidelines are appropriate for healthy individuals, inactive adults and clinical populations may have significant limitations to using the load of RT recommended for ACSM; therefore, other options are necessary to improve musculoskeletal fitness (Chulvi-Medrano, 2011). For these populations, low-load resistance training (20%–30% 1RM) with blood flow restriction (LL-BFR) has been deemed an alternative technique to conventional RT (Chulvi-Medrano, 2011; Jeremy Paul Loenneke & Pujol, 2009; Pope, Willardson, & Schoenfeld, 2013; Slysz, Stultz, & Burr, 2016). This training technique, also called *Kaatsu*® training, has been shown to be an effective method for increasing muscle size and strength in clinical settings and athletic populations (Amani, Sadeghi, & Afsharnezhad, 2018; Martín-Hernández, Marín, 2011; Martín-Hernández, 2011; Meester, Stodden, Brian, True, & Cardon, 2016). During LL-BFR exercise, partial blood flow restriction of the exercised muscle is achieved by proximal compression of the limb. LL-BFR training usually consists of 2-3 sessions per week, 3-5 sets of 15 repetitions or sets carried out to volition-

Received: October 26 2018 | Accepted after revision: November 01 2018 | First published online: March 01 2019

Conflict of interest: None declared.

al failure, and 30-60-second rest intervals between sets (Martín-Hernández, 2011).

Although the exact mechanisms underlying BFRT-induced neuromuscular adaptations remain unclear, some candidates have been depicted, such as intramuscular metabolite production (i.e., lactate accumulation), increases in acute secretion of growth hormone (GH), catecholamine, and inorganic phosphate (Pi) (Loenneke, Fahs, Rossow, Abe, & Bemben, 2012; Loenneke & Pujol, 2009), depletion of muscle phosphocreatine (PCr) and decreased pH (Loenneke & Pujol, 2009). Lastly, increases of skeletal muscle fast-twitch fibres recruitment and muscle cell swelling would contribute to the stimulation of different anabolic-signalling pathways (Loenneke et al., 2012).

Nutritional supplementation combined with RT has been shown to yield significant increases in muscle size, strength, and power in greater magnitude than RT alone (Buford et al., 2007; Helms, Aragon, & Fitschen, 2014; Pearson, Hamby, Russel, & Harris, 1999). Specifically, creatine monohydrate (CrM) and hydroxymethyl butyrate (HMB) supplementation combined with RT have been shown to be effective for inducing neuromuscular adaptations in trained and untrained individuals (Buford et al., 2007; Helms et al., 2014; Portal, Eliakim, Nemet, Halevy, & Zadik, 2010; Wilson et al., 2013). Oral intake of CrM increases both intramuscular creatine and phosphocreatine concentrations leading to a concomitant increase in body mass and performance (Balsom, Söderlund, & Ekblom, 1994; Birch, Noble, & Greenhaff, 1994; Helms et al., 2014). These ergogenic effects may be caused by the availability of the amino acid leucine and some derivative metabolites, since the β-isocaproate inhibits proteolysis (Nair, Schwartz, & Welle, 1992; Nissen et al., 1996). The positive effects of RT with HMB supplementation are also consistent. Jówko et al. (2001) demonstrated in untrained individuals that the increases skeletal muscle mass and strength following RT with HMB were superior in comparison to those obtained with RT alone after 3 weeks of training. In addition, Wilson et al. (2014) found that this strategy was effective to enhance RT training-induced gains in strength, power, and muscle mass in resistance-trained males.

While there is a growing body of evidence highlighting the potential benefits of LL-BFR exercise on skeletal muscle hypertrophy and strength, the effects of this strategy combined with nutritional supplementation on neuromuscular adaptations responses remain unknown.

Therefore, this study aimed to investigate the effects of an LL-BFR exercise programme with and without CrM and HMB supplementation on skeletal muscle hypertrophy and strength adaptations. We hypothesized that the LL-BFR-induced hypertrophy and strength increases combined with CrM and HMB would overcome those obtained with LL-BFR alone, since the CrM and HMB supplementation combined with conventional RT has shown a synergistic effect (Jówko et al., 2001).

Methods and materials

Participants

Fifteen healthy male untrained college students (age: 23.3 ± 2.6 years; body mass: 78.1 ± 12.68 kg; height 1.78 ± 0.07 m) were recruited to participate in this study. The participants were randomly allocated to one of the three groups: a) blood flow restriction without supplementation (C-BFR, n=5), b) blood flow restriction with creatine monohydrate supplementation (CrM-BFR, n=5), and c) blood flow restriction with creatine monohydrate plus hydroxymethyl butyrate supplementation (CrM + HMB-BFR, n=5). The criteria for inclusion in the study were: resistance-trained men who were 20-30 years old with at least 6 months of experience in RT. Participants with cardiovascular risk, food intolerances, or specific allergies to the supplements, neuromuscular disorders or any acute or chronic disease were excluded from the study. Likewise, all participants should not have used nutritional supplementation or drugs within six months prior to the commencement of the study. The study was approved by the Ethics Committee of the University of Valencia (procedure number H1419281092018) and conducted accordingly with the Declaration of Helsinki. Following the explanation about the risks and benefits of this study, participants signed their written informed consent.

Procedures

Anthropometric measurements (body mass, height, body mass index), maximal isometric voluntary contraction (MIVC), biceps muscle thickness (BMT), and total occlusion pressure (TOP) were obtained prior the study. After two familiarization sessions of testing and protocols, participants were randomly divided into three training groups: a) blood flow restriction without supplementation (C-BFR), b) blood flow restriction with creatine monohydrate supplementation (CrM-BFR), and c) blood flow restriction with creatine monohydrate plus hydroxymethyl butyrate supplementation (CrM + HMB-BFR). All participants performed the biceps curl exercise at 30% of MIVC and 30% of TOP, 3 sets of 15 repetitions, twice per week, for three weeks. Elbow flexion strength and biceps muscle thickness were assessed before and after training.

Participant's characteristics and anthropometric measurements

Body mass (kg) was measured with the participants in a standing position on electrical bioimpedance equipment (Omrom - HbF-510W), and height (m) was measured with each participant at the same position on a stadiometer (Seca® 217).

Maximal isometric voluntary contraction (MIVC). Isometric strength was evaluated through MIVC from the dominant arm of each participant using a load cell (Mutonic® SP51 "HiLine" V6.10). The participants

DOI 10.26773/mjssm.190306

were placed in a standing position, and their elbow positioned at 90º of flexion and monitored with an analogic goniometer. Participants performed two attempts of maximal voluntary isometric contractions for five seconds, with rest periods of 180s between them. In short, participants were instructed to perform an elbow flexion action as forcefully as possible during contraction time. The highest value of two attempts was used for statistical analysis.

Bicep muscle thickness. Bicep muscle thickness was recorded using an ultrasonographic technique (Sonosite M-Turbo). The measurements were performed with the participants in a supine position with their arms extended and relaxed. Before measurements, the participants rested for 15 min to allow fluid shifts to occur and all muscle thickness measurements were performed by an experienced physiotherapist. Biceps muscle thickness values were measured by placing the probe perpendicular without depressing the skin at the specific landmark that was identified at 60% of the distance from the acromion process of the scapula to the lateral epicondyle of the humerus.

Total occlusion pressure (TOP). The value of TOP was individually registered through Doppler ultrasound. For this measure, a pressure cuff (57 cm length × 9 cm width; Riester Komprimeter, Riester, Jungingen, Germany) was attached to participant's axillar region and then progressively inflated, while the arterial blood flow was monitored using Doppler ultrasound. When brachial arterial blood flow was interrupted, the arterial occlusion pressure level was recorded (100% of TOP). For all BFR protocols, 30% of TOP was used.

Training protocols. Prior to starting the training protocols, participants performed two familiarization sessions with LL-BFR exercise at 20% of MIVC and 20% of TOP. A 48h interval was allowed between familiarization sessions and testing before starting the training programme. For training protocols, all participants performed the biceps curl exercise at 30% of MIVC and 30% of TOP individual with the dominant arm. In each training session, the participants performed 3 sets of 15 repetitions with a 60-second interval between sets and a contraction cycle duration of 2 seconds in the concentric phase and 2 seconds in the eccentric phase. The pressure restriction was maintained throughout the exercise and rest intervals. The training programme was carried out with a frequency of 2 days per week (Monday and Thursday), for 3 weeks. All training sessions were supervised by a personal trainer.

Nutritional supplementation. Prior to the study, participants recorded their dietary pattern for a week, and a nutritionist instructed the participants to maintain their normal diet based on the data collected in the study. Besides normal dietary, the participants from the CrM-BFR group was supplemented with creatine monohydrate (rate of 0.3 g/kg body mass), whereas the participants from CrM + HMB-BFR group received the same amount of creatine monohydrate of the CrM-BFR group combined with 3g of supplementation of hydroxymethyl butyrate (Scitec Nutrition®). The C-BFR group received no supplementation. Nutritional supplementation doses used in this study were based on the findings of previous studies (Buford et al., 2007; Wilson et al., 2013). Nutritional supplementation was administered 10 minutes before beginning each training session in a double-blind fashion.-

Statistical analysis

The results are presented as mean and standard deviations (SD). The comparison between paired samples (intragroup) was carried out using a *t*-test to compare maximal isometric voluntary contraction and biceps muscle thickness in each group before and after the training programme. Adjustment for multiple comparisons was made with Bonferroni's correction. The analysis of variance (two-factor ANOVA) was also performed followed by *post hoc* DMS multiple comparisons to make intergroup comparisons. The level of significance was set at $p<0.05$. SPSS 18.0 software, licensed from the University of Alicante, was used for statistical analysis. The effect size was calculated using the Cohen test ([post-test mean –pre-test mean] / pre-test standard deviation). To determine the effect size of the intervention, applied the values for trained subjects were applied (Rhea, 2004): trivial effect d<0.25; small effect d= 0.25 – 0.50; moderate effect d= 0.50-1.0; large effect d>1.0. Finally, the percentage increase in each group was calculated using the following formula: (post-intervention mean – pre-intervention mean) / pre-intervention mean × 100.

Results

Maximal isometric voluntary contraction

There was no time effect × interaction for MIVC for all groups from pre to post-test ($p>0.05$). MIVC was increased in 11.20%, 31.60%, and 3.66% in the C-BFR, CrM-BFR and CrM + HMB-BFR groups, respectively, from pre- to post-training (Table 1). No significant increase was found between groups at pre-test and post-test ($p>0.05$).

TABLE 1 Maximal Isometric Voluntary Contraction for C-BFR, CrM-BFR, and CrM + HMB-BFR Groups from Pre- to Post-test

Groups	Pre-test M±SD (in kg)	Post-test M±SD (in kg)	*p*	*Cohen d*
C-BFR	17.04±2.7	18.97±3.17	0.444	0.71
CrM-BFR	14.24±5.7	18.74±4.06	0.094	0.78
CrM + HMB-BFR	16.08±2.9	16.67±3.5	0.377	0.20

Biceps muscle thickness

There was a significant main effect of time and group interaction for biceps muscle thickness ($p<0.05$). Biceps muscle thickness was increased in 12.5%, 8.88%, and 13.12% in the C-BFR, CrM, and CrM + HMB-BFR groups respectively, from pre- to post-training (Table 2). There was a significant difference between the C-BFR group and CrM + HMB-BFR group at post-training ($p<0.05$).

TABLE 2 Outcomes for the Biceps Muscle Thickness Before (pre-test) And After (post-test) Intervention

Groups	Pre-test M±SD (in kg)	Post-test M±SD (in kg)	*p*	*Cohen d*
C-BFR	3.52±0.20	3.96±0.15	0.003* †	2.2
CrM-BFR	3.49±0.31	3.80±0.25	0.031*	1.0
CrM + HMB-BFR	3.20±0.33	3.62±0.17	0.048*	1.27

Note: *Significant difference from pre- to post-training ($p<0.05$); †Significant difference between C-BFR group and CrM + HMB-BFR group at post-training ($p<0.05$).

Discussion

The main findings of this investigation were: a) Isometric strength was not influenced by blood flow restriction training or nutritional supplementation; b) Low-load RT with blood flow restriction induced increases in biceps muscle hypertrophy regardless of nutritional supplementation.

Maximal isometric strength

Despite the fact that other studies have demonstrated an advantage in strength gains in applying low-load resistance training with blood flow restriction compared to the same protocol without BFR (Slysz et al., 2016) and a similarity to high-load resistance training (Laurentino et al., 2012; Takarada et al., 2000), in our study we did not observe changes in isometric peak torque of elbow flexors following 3 weeks of BFRT. Similar findings were reported in a recent study in which the isometric peak torque of the knee extensors was not significantly changed following 6 weeks BFRT (Cook, Scott, Hayes, & Murphy, 2018). In addition, in this study, a reduction of 2% in the central activation was observed. These results suggest that the involvement of the central nervous system following BFR resistance exercise as strength improvements may not be of neural origin.

In contrast, in Cook's study, a significant increase of 13% in leg extension 1RM was observed. Although we did not evaluate elbow flexors 1RM in our study, it has been suggested that nonspecific strength assessment, such as in isometric of isokinetic testing, may more precisely reflect the response to different training protocols (Buckner et al., 2017). Regarding the overall strength observed in the present study, we can speculate that the training mode through of isotonic contractions and the lack of significant change in isometric muscle strength may mask neural adaptations assessed through an isometric contraction. Altogether, the low interference of LL-BFR on neural adaptation and testing specificity could have influenced the response in strength gains after the training period. However, short-term training (3 weeks) perhaps would have been insufficient to reach significant changes in strength following LL-BFR.

Muscle hypertrophy and nutritional supplementation

Regarding increases in muscle mass, our results showed that BFR protocols were efficient to increase muscle hypertrophy, regardless of nutritional supplementation. These data are consistent, since a variety of studies has pointed out higher muscle mass gain in LL-BFR in comparison to LL without BFR (Slysz et al., 2016) and similar effects to high-load resistance exercise (Laurentino et al., 2012; Martín-Hernández et al., 2013). However, no study to our knowledge has investigated the effect of nutritional supplementation combined with LL-BFR on muscle size. The Position Stand of the International Society of Sports Nutrition has demonstrated the ergogenic effects of supplementation of CrM combined with RT (Buford et al., 2007). For instance, Souza-Junior et al. (2011) reported increases in maximal strength, isokinetic peak torque and muscle mass after 8 weeks of RT programme (8-10 RM) in bench press and back squat exercises associated with the supplementation of 20 g of CrM. In another study, Antonio and Ciccone (2013) demonstrated that 5g of creatine monohydrate ingestion post-exercise, twice a week, induced increase in fat-free mass and loss of fat mass following a 4-week periodized-resistance training programme (3 sets × 5-10 reps).

Previous research has evaluated the effectiveness of CrM combined with HMB supplementation on muscle mass and strength gains, and the results are conflicting (Jówko et al., 2001; O'Connor & Crowe, 2007). Jówko et al. (2001) reported significant increases in muscle mass and strength in a group supplemented with CrM + HMB compared to a placebo-supplemented group after three weeks of RT using a progressive load programme. In contrast, O'Connor and Crowe (O'Connor & Crowe, 2007) demonstrated no additional effect of oral co-administration of CrM (3g) and HMB (3g) on muscle strength after six weeks of RT. Our results showed no additional effect of HMB and CrM plus HMB supplementation associated with LL-BFR on increases in muscle mass and maximum isometric strength. These data are in accordance with those obtained in a recent metanalysis published by Sanchez-Martinez et al. (2018), which highlighted no ergogenic effect of HMB on the morphological and functional musculoskeletal system in trained subjects.

DOI 10.26773/mjssm.190306

Lastly, the discrepancies between our findings compared to the previous studies regarding nutritional supplementation combined with LL-BFR may be, at least partially, explained by the differences in the dose of supplementation, the duration of the study, and the load used in LL-BFR protocols.

In conclusion, three weeks of LL-BFR induced increases in muscle hypertrophy but not on strength gains. In addition, CrM and CrM plus HMB supplementation showed no additional effect of LL-BFR-induced neuromuscular adaptations.

The current study reveals some potential limitations. First, this is a preliminary study, and the small sample size limits statistical power. Second, the lack of dietary monitoring using a normalized isocaloric diet also could have affected our results. Third, an LI-BFR with HMB supplementation and placebo groups could be included in study design. Lastly, the duration of this study could be longer (more than 4-6 weeks). -

Acknowledgements
The authors would like to thank all the participants of this study, as well as Miguel García-Jaén who participated in this study supported by a pre-doctoral grant ACIF/2016/048 from the Generalitat Valenciana, Spain.

REFERENCES

Amani, A. R., Sadeghi, H., & Afsharnezhad, T. (2018). Interval Training with Blood Flow Restriction on Aerobic Performance among Young Soccer Players at Transition Phase. *Montenegrin Journal of Sports Science and Medicine*, *7*(2), 5-10. doi: 10.26773/mjssm.180901

American College of Sports Medicine. (2009). Progression Models in Resistance Training for Healthy Adults. *Medicine & Science in Sports & Exercise*, *41*(3), 687–708. doi: 10.1249/MSS.0b013e3181915670

Antonio, J., & Ciccone, V. (2013). The effects of pre versus post workout supplementation of creatine monohydrate on body composition and strength. *Journal of the International Society of Sports Nutrition*, *10*(1), 36. doi: 10.1186/1550-2783-10-36

Balsom, P. D., Söderlund, K., & Ekblom, B. (1994). Creatine in humans with special reference to creatine supplementation. *Sports Medicine (Auckland, N.Z.)*, *18*(4), 268–280. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/7817065

Birch, R., Noble, D., & Greenhaff, P. L. (1994). The influence of dietary creatine supplementation on performance during repeated bouts of maximal isokinetic cycling in man. *European Journal of Applied Physiology and Occupational Physiology*, *69*(3), 268–276. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/8001541

Buckner, S. L., Mouser, J. G., Dankel, S. J., Jessee, M. B., Mattocks, K. T., & Loenneke, J. P. (2017). The General Adaptation Syndrome: Potential misapplications to resistance exercise. *Journal of Science and Medicine in Sport*, *20*(11), 1015–1017. doi: 10.1016/j.jsams.2017.02.012

Buford, T. W., Kreider, R. B., Stout, J. R., Greenwood, M., Campbell, B., Spano, M., … Antonio, J. (2007). International Society of Sports Nutrition position stand: creatine supplementation and exercise. *Journal of the International Society of Sports Nutrition*, *4*(1), 6. doi: 10.1186/1550-2783-4-6

Chulvi-Medrano, I. (2011). Resistance training combined with superimposed partial occlusion. A review. *Revista Andaluza de Medicina Del Deporte*, *4*(3), 121–128.

Cook, S. B., Scott, B. R., Hayes, K. L., & Murphy, B. G. (2018). Neuromuscular Adaptations to Low-Load Blood Flow Restricted Resistance Training. *Journal of Sports Science & Medicine*, *17*(1), 66–73. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/29535579

Helms, E. R., Aragon, A. A., & Fitschen, P. J. (2014). Evidence-based recommendations for natural bodybuilding contest preparation: nutrition and supplementation. *Journal of the International Society of Sports Nutrition*, *11*(1), 20. doi: 10.1186/1550-2783-11-20

Jówko, E., Ostaszewski, P., Jank, M., Sacharuk, J., Zieniewicz, A., Wilczak, J., & Nissen, S. (2001). Creatine and beta-hydroxy-beta-methylbutyrate (HMB) additively increase lean body mass and muscle strength during a weight-training program. *Nutrition (Burbank, Los Angeles County, Calif.)*, *17*(7–8), 558–566. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/11448573

Laurentino, G. C., Ugrinowitsch, C., Roschel, H., Aoki, M. S., Soares, A. G., Neves, M., … Tricoli, V. (2012). Strength training with blood flow restriction diminishes myostatin gene expression. *Medicine and Science in Sports and Exercise*, *44*(3), 406–412. doi: 10.1249/MSS.0b013e318233b4bc

Loenneke, J. P., Fahs, C. A., Rossow, L. M., Abe, T., & Bemben, M. G. (2012). The anabolic benefits of venous blood flow restriction training may be induced by muscle cell swelling. *Medical Hypotheses*, *78*(1), 151–154. doi: 10.1016/j.mehy.2011.10.014

Loenneke, J. P., & Pujol, T. J. (2009). The Use of Occlusion Training to Produce Muscle Hypertrophy. *Strength and Conditioning Journal*, *31*(3), 77–84. doi: 10.1519/SSC.0b013e3181a5a352

Martín-Hernández, J, Marín PJ, H. A. (2011). Review of muscle hypertrophy mechanisms induced by resistance occlusive training. *Revista Andaluza de Medicina Del Deporte*, *4*(4), 129–177.

Martín-Hernández, J, B. R. H. A. (2011). Physical exercise supplemented with tisular ischemia prevents muscle atrophy. *Archivos de Medicina Del Deporte*, *28*(145), 383–393.

Martín-Hernández, J., Marín, P. J., Menéndez, H., Ferrero, C., Loenneke, J. P., & Herrero, A. J. (2013). Muscular adaptations after two different volumes of blood flow-restricted training. *Scandinavian Journal*

of Medicine & Science in Sports, *23*(2), e114-20. doi: 10.1111/sms.12036

Meester, A. De, Stodden, D., Brian, A., True, L., & Cardon, G. (2016). Associations among Elementary School Children's Actual Motor Competence, Perceived Motor Competence , Physical Activity and BMI : A Cross-Sectional Study Associations among Elementary School Children's Actual Motor Competence, Perceived Motor Compet, (October), 1–14. doi: 10.5061/dryad.96cp2

Nair, K. S., Schwartz, R. G., & Welle, S. (1992). Leucine as a regulator of whole body and skeletal muscle protein metabolism in humans. *American Journal of Physiology-Endocrinology and Metabolism*, *263*(5), E928–E934. doi: 10.1152/ajpendo.1992.263.5.E928

Nissen, S., Sharp, R., Ray, M., Rathmacher, J. A., Rice, D., Fuller, J. C., … Abumrad, N. (1996). Effect of leucine metabolite beta-hydroxy-beta-methylbutyrate on muscle metabolism during resistance-exercise training. *Journal of Applied Physiology (Bethesda, Md. : 1985)*, *81*(5), 2095–2104. doi: 10.1152/jappl.1996.81.5.2095

O'Connor, D. M., & Crowe, M. J. (2007). Effects of Six Weeks of β-Hydroxy-β-Methylbutyrate (HMB) and HMB/Creatine Supplementation on Strength, Power, and Anthropometry of Highly Trained Athletes. *The Journal of Strength and Conditioning Research*, *21*(2), 419. doi: 10.1519/R-15974.1

Pearson, D.R., Hamby, D.G., Russel, W., & Harris, T. (1999). Long-term effects of creatine monohydrate on strength and power. *Journal of Strength and Conditioning Research*, *13*(3), 187–192.

Pope, Z. K., Willardson, J. M., & Schoenfeld, B. J. (2013). Exercise and blood flow restriction. *Journal of Strength and Conditioning Research*, *27*(10), 2914–2926. doi: 10.1519/JSC.0b013e3182874721

Portal, S., Eliakim, A., Nemet, D., Halevy, O., & Zadik, Z. (2010). Effect of HMB supplementation on body composition, fitness, hormonal profile and muscle damage indices. *Journal of Pediatric Endocrinology & Metabolism : JPEM*, *23*(7), 641–650. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/20857835

Rhea, M. R. (2004). Determining the Magnitude of Treatment Effects in Strength Training Research Through the Use of the Effect Size. *The Journal of Strength and Conditioning Research*, *18*(4), 918. doi: 10.1519/14403.1

Sanchez-Martinez, J., Santos-Lozano, A., Garcia-Hermoso, A., Sadarangani, K. P., & Cristi-Montero, C. (2018). Effects of beta-hydroxy-beta-methylbutyrate supplementation on strength and body composition in trained and competitive athletes: A meta-analysis of randomized controlled trials. *Journal of Science and Medicine in Sport*, *21*(7), 727–735. doi: 10.1016/j.jsams.2017.11.003

Slysz, J., Stultz, J., & Burr, J. F. (2016). The efficacy of blood flow restricted exercise: A systematic review & meta-analysis. *Journal of Science and Medicine in Sport*, *19*(8), 669–675. doi: 10.1016/j.jsams.2015.09.005

Souza-Junior, T. P., Willardson, J. M., Bloomer, R., Leite, R. D., Fleck, S. J., Oliveira, P. R., & Simão, R. (2011). Strength and hypertrophy responses to constant and decreasing rest intervals in trained men using creatine supplementation. *Journal of the International Society of Sports Nutrition*, *8*(1), 17. doi: 10.1186/1550-2783-8-17

Takarada, Y., Takazawa, H., Sato, Y., Takebayashi, S., Tanaka, Y., & Ishii, N. (2000). Effects of resistance exercise combined with moderate vascular occlusion on muscular function in humans. *Journal of Applied Physiology*, *88*(6), 2097–2106. doi: 10.1152/jappl.2000.88.6.2097

Wilson, J. M., Fitschen, P. J., Campbell, B., Wilson, G. J., Zanchi, N., Taylor, L., … Antonio, J. (2013). International Society of Sports Nutrition Position Stand: beta-hydroxy-beta-methylbutyrate (HMB). *Journal of the International Society of Sports Nutrition*, *10*(1), 6. doi: 10.1186/1550-2783-10-6

Wilson, J. M., Lowery, R. P., Joy, J. M., Andersen, J. C., Wilson, S. M. C., Stout, J. R., … Rathmacher, J. (2014). The effects of 12 weeks of beta-hydroxy-beta-methylbutyrate free acid supplementation on muscle mass, strength, and power in resistance-trained individuals: a randomized, double-blind, placebo-controlled study. *European Journal of Applied Physiology*, *114*(6), 1217–1227. doi: 10.1007/s00421-014-2854-5

DOI 10.26773/mjssm.190306

ORIGINAL SCIENTIFIC PAPER

The Important Game-Related Statistics for Qualifying Next Rounds in Euroleague

Ilkay Dogan[1], Yasin Ersoz[2]

Affiliations: [1]Gaziantep University, Faculty of Medicine, Department of Biostatistics, Gaziantep, Turkey, [2]Mersin University, School of Physical Education and Sports, Mersin, Turkey

Correspondence: I. Dogan, Gaziantep University, Faculty of Medicine, Department of Biostatistics, 27310 Gaziantep, Turkey. E-mail: ilkaydogan@gantep.edu.tr

ABSTRACT Euroleague is one of the most popular professional indoor sports leagues in the world. It is globally ranked as the fifth-highest professional indoor sports league and the second-highest professional basketball league, just trailing behind the National Basketball Association (NBA). The objective of this study was to determine which game-related statistics can assist in predicting the team that will qualify for the next rounds of the Euroleague. The data used in the study were obtained from each team's official average box score on the Euroleague website for 2010-2017. The datasets were arranged into two groups depending on the qualification of the teams into the subsequent round. Discriminant analysis was applied to find the game-related statistics that better contribute to qualifying for the next round. A three-point field-goal percentage was considered to be an essential variable in every round. However, it was also observed that, contrary to expectations, offensive rebounds had a negative effect in the final four rounds. It is recommended these results be used to plan the team strategies and the player strategies accordingly in a long-term and demanding tournament like Euroleague.

KEY WORDS basketball, Euroleague, discriminant analysis, game-related statistics

@MJSSMontenegro
GAME-RELATED STATISTICS IN EUROLEAGUE
http://mjssm.me/?sekcija=article&artid=172

Introduction

Euroleague is one of the most popular professional indoor sports leagues in the world, and perhaps Euroleague is the most watched after the National Basketball Association (NBA, superior level) in the USA. In recent years, NBA teams have played pre-season matches with Euroleague teams, which is an indication that Euroleague is seen as competitive to the NBA. Euroleague Basketball is considered to be a global leader in sport and basketball. Euroleague is composed of 16 teams; each team plays each other twice, and in these two games, one game is played on the home court while the other game is played on the opponent's court. The games in Euroleague are played in a true league-style season format with a total of 30 games. The top eight teams at the end of the regular season advance to the playoffs, which are held as a five-game play-off series. The higher placed team in the regular season standings of each playoff match-up has home court advantage in each play-off series, playing three out of the five games at home. The winners of each four playoff series advance to the final four, which is held at a predetermined site. The final four games feature two semi-final games, a third-place game, and finally the championship game. Each team plays a maximum of 37 games per season, versus 31 games in the previous tournament format.

The European sports clubs make sizeable investments to join the Euroleague as well as to succeed in the competitions within this league. In order to qualify for the next rounds in Euroleague, even the slightest details on winning and losing a match become very important. The success of basketball teams in the competitions depends on several factors which include physiological fitness, psychological preparedness, biomechanical proficiency, anthropometric characteristics, and tactical awareness (Glazier, 2017). The results of a game or other sporting event depend not only on the skill of the participants but also on "luck" and randomness, and separating the contribution of skill from that of luck is not always easy (Severini, 2014). A high level of team features, including skill, tactical awareness, and anthropometric characteristics produce game-related statis-

Received: August 28 2018 | Accepted after revision: November 09 2018 | First published online: March 01 2019

Conflict of interest: None declared.

tics and help create success. The game-related statistics enable the preparation of prospective studies using statistical methods to build the team characteristics (skills, psychological preparedness, anthropometric characteristics, etc.) for success. Game-related statistics have been used to describe the variables that can help to differentiate the successful teams in the league versus the other teams. This allows relating the performance of teams using technical and tactical indicators derived during the game and, as a result, it improves the success of the training programmes (Ribas et al., 2011). Discovering unique situations in the game allows identifying the dispositions of the evolution of the game played by the players, and thus it helps to optimize the preparation process of the teams for the upcoming games (Hughes & Franks, 2004). Therefore, basketball and other sports cannot be considered separately from statistics.

In recent years statistical data collection during basketball games has been frequently used, and researchers use advanced statistical methods with an analysis of the performance of the games and the recognition of trends and models that are found to be dominant in the game (Sampaio et al., 2006; Sampaio et al., 2010a; Ergül, 2014; Čaušević, 2015; Doğan et al., 2016). With the utilization of notational analysis, basketball has become one of the most analysed sports in the world (Lorenzo et al., 2010) and the investigation on this subject has focused on discriminately identifying the winning and losing teams during the regular season and during the playoff games (Dogan et al., 2016; García et al., 2013; Ibánez et al., 2008; Ittenbach and Esters, 1995; Sampaio et al., 2010b; Taxildaris et al., 2001). Previously, studies on the performance analysis of some national basketball leagues were conducted (Dežman et al., 2002; Gimenez and Janeira, 2003; Sampaio et al., 2004).

García et al. (2013) suggested that the winning teams dominated in assists, defensive rebounds, and successful two- and three-point field goals in regular season games at the ACB Spanish League. However, they also showed that the superiority of the winning teams was observed only during the defensive rebounding in the playoff games. Other research examined the differences in game-related statistics between basketball guards, forwards, and centre players who were playing in three different professional leagues; it was observed that the game-related statistics of the players varied according to their position (Sampaio et al., 2006). For example, Ibáñez et al. (2008) conducted the game-related statistics that discriminated the winning and losing teams in basketball in the context of three consecutive games played in a condensed tournament format. The results of their study showed that the winning teams in this competition had better values in all of the game-related statistics, with the exception of three-point field goals, missed free throws, and turnovers.

Although discriminant game-related statistics show different variables, which depend upon the specific context of the games, there are certain variables for performance that are especially considered for the games in the regular season and the play-off period. Therefore, different game-related statistics may function as a discriminant in other specific contexts, such as three-point field goal attempts and assists (Gómez et al., 2008) in different style competitions (such as the world championships). For example, in the playoff games of the ACB Spanish Basketball League, it was observed that the superiority of the winning teams was only in defensive rebound situations (García et al., 2013).

There is a limited number of research studies about game-related statistics, despite Euroleague being such a high-level basketball organization (Sampaio et al., 2010b; Ribas et al., 2011; Marmarinos et al., 2016; Çene, 2018). Although game-related statistics can be influenced some characteristics; such as play-off games strategies, league structure, team dynamic, quality of the players; it may show differences for each round in the Euroleague season. It may help coaches who are competing in this quality and structure of the league to prepare team practice and game planning. In this context, the objective of this study was to identify which game-related statistics can assist in predicting the team that will qualify for the next rounds such as the first round, top sixteen, play-off, and final four of the Euroleague.

Methods

Sample and variables

The data for indicating team performance were obtained from each team's official average box score in the Euroleague's website for the 2010-2017 seasons (www.euroleague.net). In this context, game-related statistics such as two-point field-goal percentage (2FG), three-point field-goal percentage (3FG), free-throw percentage (FT), offensive rebound (OffReb), defensive rebound (DefReb), assists (As), steals (St), turnovers (To), blocks in favour (Fv), blocks against (Ag), fouls committed (Cm), and fouls received (Rv) were gathered. The average box scores of the teams for each round (first round, top sixteen, play-off, and final four) were evaluated separately. In the 2016-2017 season, the format of the tournament was changed, and the number of teams was reduced. Thus, the teams have directly competed in a single group of 16 teams (www.euroleague.net). Therefore, there is no data available for the 2016-2017 season in the first-round data set. During the study, the datasets were arranged into two groups according to whether the teams qualified for the next round. The data analysis was carried out by categorizing these two groups as "qualified (represented as F1)" and "eliminated (represented as F2)".

Statistical Analysis

Discriminant analysis was applied to find the game-related statistics that better contribute to qualifying for the next round. Discriminant analysis is a method that develops distinguishing functions between the group mean vectors for separating the groups entered into each other with common features (Özdamar, 2013). The

DOI 10.26773/mjssm.190307

interpretation of the obtained discriminant functions was based on the examination of the structure coefficients greater than |0.30| which means that the variables with higher absolute values have a stronger contribution to discriminate between the groups (Tabachnick & Fidell, 2000). Discriminant analysis is categorized into two main groups: as linear and quadratic discriminant analysis. The linear discriminant analysis assumes that the covariance matrices of all groups are homogenous. The quadratic discriminant analysis does not use the assumption that the covariance matrices of all the groups are homogenous (Özdamar, 2013). In the present study, it was found that the group's covariance matrices were homogeneous for each dataset as a result of a Box'M test (p>0.05). Therefore, the linear discriminant analysis was selected to be used in this study. The statistical analyses were performed using SPSS software, and significance was set at p<0.05.

Results

The results of the discriminant analysis for qualifying from the first round are represented in Table 1. According to Table 1, the discriminant function for determining (separating) the group based on the data has a significant separation (p<0.05). Moreover, the correct classification rate of the discriminant function is 75.0%. Considering the discriminant functions' coefficients, discriminant functions can be written as follows,

$$F_1 = -618.628 + 7.025\,2FG + 3.423\,3FG + 3.486\,FT + 9.472\,OffReb + 4.999\,DefReb - 2.471\,As + 4.095\,St + 3.709\,To - 0.843\,Fv + 8.113\,Ag + 6.377\,Cm + 3.795\,Rv$$

$$F_2 = -583.641 + 6.825\,2FG + 3.261\,3FG + 3.471\,FT + 9.038\,OffReb + 4.693\,DefReb - 2.433\,As + 4.026\,St + 3.814\,To - 1.373\,Fv + 8.728\,Ag + 6.567\,Cm + 3.194\,Rv$$

From 2010 to 2017 in the Euroleague seasons, the two-point field-goal percentage (SC=0.501), defensive rebound (SC=0.495), fouls received (SC=0.486), and blocks in favour (SC=0.466) are the game-related statistics that have the major contribution to the teams' qualifying to the top sixteen. Furthermore, the other variables that contribute to the qualifying of the team are assists (SC=0.345) and the three-point field-goal percentage (SC=0.302), respectively.

TABLE 1 Discriminant analysis results for the first round

Discriminant Function Coefficients			**Structure Coefficients**
Variables	**Function 1 (Qualified)**	**Function 2 (Eliminated)**	**Function 1**
2-point field-goal percentage (2FG)	7.025	6.825	**0.501**
3-point field-goal percentage (3FG)	3.423	3.261	**0.302**
Free-throw percentage (FT)	3.486	6.471	0.150
Offensive rebound (OffReb)	9.472	9.038	0.152
Defensive rebound (DefReb)	4.999	4.693	**0.495**
Assists (As)	-2.471	-2.433	**0.345**
Steals (St)	4.095	4.026	0.109
Turnovers (To)	3.709	3.814	-0.119
Blocks in favour (Fv)	-0.843	-1.373	**0.466**
Blocks against (Ag)	8.113	8.728	-0.224
Fouls committed (Cm)	6.377	6.567	-0.175
Fouls received (Rv)	3.795	3.194	**0.486**
(Constant)	-618.628	-583.641	
Box's M test		F=1.024; p=0.420	
Wilks' Lambda		0.609	
Eigenvalue		0.641	
Chi-Square		67.386	
p		0.000	
Canonical Correlation		0.625	
Reclassification (%)		75.0	

The results of the discriminant analysis for qualifying from the top sixteen are represented in Table 2. The discriminant function for determining (separating) the group based on the data has a significant separation (p<0.05). Moreover, the correct classification rate of the discriminant function is 84.8%. Discriminant functions can be written as follows,

$$F_1 = -811.544 + 10.538\,2FG + 5.144\,3FG + 3.918\,FT + 10.423\,OffReb + 10.263\,DefReb - 6.586\,As + 6.958\,St + 4.747\,To - 6.282\,Fv + 18.594\,Ag + 5.172\,Cm + 4.941\,Rv$$

$$F_2 = -783.897 + 10.284\,2FG + 4.882\,3FG + 3.979\,FT + 10.375\,OffReb + 9.758\,DefReb - 6.213\,As + 6.169\,St + 5.334\,To - 6.686\,Fv + 18.643\,Ag + 5.373\,Cm + 4.502\,Rv$$

From 2010 to 2017 in the Euroleague seasons, the two-point field-goal percentage (SC=0.462), blocks in favour (SC=0.458), and turnovers (SC= -0.401) are the game related statistics that have the major contribution to teams' qualifying for the play-offs. Furthermore, the other variables that contribute to the qualifying of the team are the three-point field-goal percentage (SC=0.372), defensive rebound (SC=0.362), and fouls received (SC=0.314), respectively.

TABLE 2 Discriminant analysis results for the top sixteen

Discriminant Function Coefficients			**Structure Coefficients**
Variables	**Function 1 (Qualified)**	**Function 2 (Eliminated)**	**Function 1**
2-point field-goal percentage (2FG)	10.538	10.284	**0.462**
3-point field-goal percentage (3FG)	5.144	4.882	**0.372**
Free-throw percentage (FT)	3.918	3.979	0.010
Offensive rebound (OffReb)	10.423	10.375	-0.105
Defensive rebound (DefReb)	10.263	9.758	**0.362**
Assists (As)	-6.586	-6.213	0.271
Steals (St)	6.958	6.169	0.259
Turnovers (To)	4.747	5.334	**-0.401**
Blocks in favour (Fv)	-6.282	-6.686	**0.458**
Blocks against (Ag)	18.594	18.643	-0.221
Fouls committed (Cm)	5.172	5.373	-0.197
Fouls received (Rv)	4.941	4.502	**0.314**
(Constant)	-811.544	-783.897	
Box's M test		F=0.978; p=0.534	
Wilks' Lambda		0.549	
Eigenvalue		0.821	
Chi-Square		62.349	
p		0.000	
Canonical Correlation		0.672	
Reclassification (%)		84.8	

According to Table 3, the discriminant function for determining (separating) the group based on the data has a significant separation ($p<0.05$). Moreover, the correct classification rate of the discriminant function is 82.1%. Discriminant functions can be written as follows,

$$F_1 = -502.589 + 5.565\,2FG + 3.703\,3FG + 3.578\,FT + 7.120\,OffReb + 8.849\,DefReb - 4.422\,As + 5.589\,St - 5.414\,To + 1.603\,Fv + 16.745\,Ag + 2.724\,Cm + 0.722\,Rv$$

$$F_2 = -461.627 + 5.409\,2FG + 3.393\,3FG + 3.433\,FT + 6.636\,OffReb + 8.443\,DefReb - 4.340\,As + 5.014\,St - 4.762\,To + 0.957\,Fv + 16.937\,Ag + 2.814\,Cm + 0.564\,Rv$$

From 2010 to 2017 in the Euroleague seasons, the three-point field-goal percentage (SC=0.494) is the game related statistic that has the major contribution to teams qualifying for the final four. Furthermore, the other variables that contribute to the qualifying of the team are assists (SC=0.333), blocks in favour (SC=0.308), and defensive rebound (SC=0.300), respectively.

TABLE 3 Discriminant analysis results for play-off

Discriminant Function Coefficients			**Structure Coefficients**
Variables	**Function 1 (Qualified)**	**Function 2 (Eliminated)**	**Function 1**
2-point field-goal percentage (2FG)	5.565	5.409	0.238
3-point field-goal percentage (3FG)	3.703	3.393	**0.494**
Free-throw percentage (FT)	3.578	3.433	0.196
Offensive rebound (OffReb)	7.120	6.636	0.063
Defensive rebound (DefReb)	8.849	8.443	**0.300**
Assists (As)	-4.422	-4.340	**0.333**
Steals (St)	5.589	5.014	0.066
Turnovers (To)	-5.414	-4.762	-0.223
Blocks in favour (Fv)	1.603	.957	**0.308**
Blocks against (Ag)	16.745	16.937	-0.294
Fouls committed (Cm)	2.724	2.814	-0.107
Fouls received (Rv)	.722	.564	0.050
(Constant)	-502.589	-461.627	
Box's M test		F=0.874; p=0.779	
Wilks' Lambda		0.465	
Eigenvalue		1.153	
Chi-Square		36.804	
p		0.000	
Canonical Correlation		0.732	
Reclassification (%)		82.1	

DOI 10.26773/mjssm.190307

The discriminant function for determining (separating) the group based on the data does not have a significant separation (p>0.05). Besides, the correct classification rate of the discriminant function is 82.1% (Table 4). Discriminant functions can be written as follows,

$$F_1 = -417.038 + 3.931\,2FG + 4.422\,3FG + 1.536\,FT + 10.336\,OffReb + 7.774\,DefReb - 4.059\,As + 12.291\,St + 9.768\,To - 7.198\,Fv + 0.330\,Ag - 3.461\,Cm + 1.154\,Rv$$

$$F_2 = -402.515 + 3.887\,2FG + 4.232\,3FG + 1.525\,FT + 10.837\,OffReb + 7.828\,DefReb - 4.113\,As + 12.540\,St + 9.753\,To - 7.635\,Fv + 0.022\,Ag - 3.605\,Cm + 0.905\,Rv$$

In the Euroleague seasons, the three-point field-goal percentage (SC=0.541) is the game-related statistic that has the major contribution to teams' being the Euroleague champion. Furthermore, the other variables that contribute to the teams' being the Euroleague champion are offensive rebounds (SC= -0.379), and the two-point field-goal percentage (SC=0.352), respectively.

TABLE 4 Discriminant analysis results for the final four

Discriminant Function Coefficients			**Structure Coefficients**
Variables	**Function 1 (Qualified)**	**Function 2 (Eliminated)**	**Function 1**
2-point field-goal percentage (2FG)	3.931	3.887	**0.352**
3-point field-goal percentage (3FG)	4.422	4.232	**0.541**
Free-throw percentage (FT)	1.536	1.525	0.161
Offensive rebound (OffReb)	10.336	10.837	**-0.379**
Defensive rebound (DefReb)	7.774	7.828	0.249
Assists (As)	-4.059	-4.113	0.298
Steals (St)	12.291	12.540	-0.191
Turnovers (To)	9.768	9.753	-0.076
Blocks in favour (Fv)	-7.198	-7.635	0.161
Blocks against (Ag)	.330	.022	0.156
Fouls committed (Cm)	-3.461	-3.605	0.249
Fouls received (Rv)	1.154	.905	0.287
(Constant)	-417.038	-402.515	
Wilks' Lambda		0.589	
Eigenvalue		0.698	
Chi-Square		10.596	
p		0.565	
Canonical Correlation		0.641	
Reclassification (%)		82.1	

Discussion and conclusions

Many studies to determine game-related statistics that influence success in basketball have been carried out by various researchers (Dežman, Erčulj, & Vučković, 2002; Doğan, Işik, & Ersöz, 2016; Gómez et al., 2008; Ibáñez et al., 2008; Lorenzo et al., 2010). However, these studies usually were conducted on national leagues around the world. It is also interesting to note that the various studies conducted about the Euroleague have been increasing in number recently (Çene, 2018; Ribas et al., 2011). This study has been the first to report the influence of game-related statistics on the box scores of Euroleague games.

The results of the study indicated that the two-point field-goal percentage, defensive rebound, fouls received, and blocks in favour were the game-related statistics that have the most contribution for analysing the teams qualifying to the top sixteen. Furthermore, it was observed that the other variables that contributed to the qualifying of the team were the assists and the three-point field-goal percentage (Table 1). The major contributing game-related statistics on teams' qualifying for the play-offs were the two-point field-goal percentage, blocks in favour, and turnovers. The other variables that contributed to the qualifying team were found to be the three-point field-goal percentage, defensive rebounds, and fouls received (Table 2). As shown in Table 2, it was observed that turnovers have a negative effect on qualification. This can be interpreted by stating that having a lesser number of turnovers will lead to having better chances to qualify for the final four teams. It was also observed that in order to qualify for the final four teams, the three-point field-goal percentage was the most important game-related statistic. Furthermore, the other variables that contributed to the qualifying of the team were found to be assists, blocks in favour, and defensive rebounds (Table 3). Most importantly, in the end, the three-points field-goal percentage was the major game-related statistic for determining the Euroleague champion. Additionally, offensive rebounds and the two-point field-goal percentage were the other variables that contributed to being the Euroleague champion (Table 4). As shown in Table 4, offensive rebounds had a negative effect on becoming the Euroleague champion. This suggests that having fewer offensive rebounds can lead to a greater chance to be the Euroleague champion.

When evaluating all rounds, the three-point field-goal percentage was seen to be an important variable in every round. However, it was also observed that as a team came closer to the finals, the importance of this variable increased. Hence, the three-point field-goal percentage was the most important game-related statistics for the play-offs as well as for the final fours. Gómez et al. (2008) emphasized the importance of three-point shots, stating that this variable can make a major difference between the winning and the losing teams. Csataljay, O'Donoghue, Hughes, and Dancs, (2009) also reported that a higher three-point shooting percentage can make the difference between winning and losing teams.

In the final four rounds, the offensive rebound was one of the most important variables. Contrary to expectations, offensive rebounds had a negative effect on becoming a Euroleague champion. This may be due to the fact that in the final four rounds, teams and coaches may have thought that it is more important to have a heavier reliance on defensive strategies. The number of positions may be fewer as a result of this strategy. Hence, the teams may have had fewer rebound positions, since they played for successful field goals. The major game-related statistics in the final four rounds (three-point field-goal percentage) supports this situation by showing the importance of successful field goals. Thus, since the final four competitions have been played as a single match, coaches may prefer these tactics exclusively for the final four rounds. These preferences and results change during the regular season of Euroleague and in the national basketball leagues. Many studies about the game-related statistics in regular seasons have shown that defensive rebounds may influence team success (Akers, Wolff, & Buttross, 1991; Sampaio and Janeira, 2003; Gómez et al. 2008; Pojskić, Šeparović, & Užičanin, 2009; García et al., 2013; Čaušević, 2015). Sampaio and Janeira (2003) pointed out the importance of defensive rebounds and also highlighted that the increase in the number of ball possessions resulted in an increase in the opportunity of offensive actions.

The other variables contributing to the qualifying of the teams to the top sixteen were fouls received and blocks in favour during the game. Despite this, in some studies, there were no differences observed between the top half teams and the bottom half teams in terms of blocks (Doğan et al., 2016; Gómez et al., 2008; Ergül, 2014). In many studies, there were also no significant results related to fouls received. Furthermore, Kozar, Vaughn, Whitfield, Lord, & Dye, (1994) revealed that, according to the data obtained from close games, the number of fouls and effectiveness of free throws were the most significant variables. García et al. (2013) reported that the winning teams dominated assists, defensive rebounds, successful two- and three-point field-goals during the regular season. However, in play-off games, the superiority of the winning teams was observed to be only in defensive rebounds. Gómez et al. (2008) suggested that in the balanced games of the regular season, the analysis emphasized defensive rebounds and successful two-point field-goals. Another study for discriminating successful and unsuccessful teams showed that the biggest contribution to the teams' discrimination were defensive rebound, two-point percentages, a number of successful two-point shots, number of assists and nonstarters points (Pojskić et al., 2009). The study by Čaušević (2015) reported that the winners could be determined from the statistics related to defensive rebounds, successful three-points, unsuccessful two-points, biggest lead, and offensive rebounds.

According to these findings, the turnovers were significant for qualifying from the top sixteen position to the play-off. Although it did not seem important for other rounds, teams needed to play with fewer turnovers in order to qualify for the play-offs. It is clear that play-off games have fewer ball possessions compared to the other games within the regular season, and that the game speed is also slower (Sampaio & Janeira, 2003) during the play-off games. Playing at a higher speed causes more unintentional errors and, hence, coaches try to minimize turnovers in important games (like the finals or the playoffs). Thus, it seems clear that in playoff games there are fewer actions due to the lower game speed; thus, every action becomes more crucial for the outcome of the game.

Although some of the defensive features in the first rounds and the top sixteen rounds were in the forefront; as the rounds progresses, the offensive features become more important. It is expected that the defensive features will be an essential element in the long season. In short tournaments, like a single game elimination system, offensive features play a decisive role for the teams. Especially when approaching the finals at senior leagues like the Euroleague, the defensive features of the teams are similar, and teams that are able to forefront offensive features are found to be more successful.

In the light of our findings, the importance of offensive and defensive features change in different rounds such long and demanding tournaments. Coaches should consider their long-term strategy carefully, and they should prepare their teams to function both for defence and offense as necessary. It may guide different aspects of team staff ,like tactical assistant coaches, team physical fitness coaches, and players' individual preparation. Coaches should form the teams in the pre-season player transfers by taking the goals of the end of the season into consideration. Coaches and players should be aware of these different viewpoints in order to increase knowledge and, therefore, to evaluate specificity at the time of practice and game planning. Coaches also should prepare their players stepwise according to Euroleague rounds. Consequently, there are several factors influencing the team success, including skill, physiological fitness, psychological preparedness, biomechanical proficiency, anthropometric characteristics, and tactical awareness. These factors can be improved with the player selection, tactical selection, and training periods. Furthermore, the result of the study may guide to coaches about in which round and how much these factors should be improved. It is recommended to form the teams, prepare the players and set the team strategies according to these results in order to achieve success in a long and demanding tournaments like Euroleague.

DOI 10.26773/mjssm.190307

Acknowledgements

We are very grateful to Euroleague Media Communication Office for allowing us to use the game-related statistics between 2010-2017 seasons of the Euroleague.

REFERENCES

Akers, M. D., Wolff, S., & Buttross, T. E. (1992). An empirical examination of the factors affecting the success of NCAA Division I College Basketball teams. *Journal of Business and Economic Studies*, *1*(2), 57-70.

Čaušević, D. (2015). Game-related statistics that discriminate winning and losing teams from the World championships in Spain in 2014. *Homo Sporticus*, *17*(2), 16-19. doi:10.1155/2012/490647

Çene, E. (2018). What is the difference between a winning and a losing team: insights from Euroleague basketball. *International Journal of Performance Analysis in Sport, 18*(1), 55-68. doi: 10.1080/24748668.2018.1446234

Csataljay, G., O'Donoghue, P., Hughes, M., & Dancs, H. (2009). Performance indicators that distinguish winning and losing teams in basketball. *International Journal of Performance Analysis in Sport*, *9*(1), 60-66. doi: 10.1080/24748668.2009.11868464

Dežman, B., Erčulj, F., & Vučković, G. (2002) Differences between winning and losing teams in playing efficiency. *Acta Kinesiologiae Universitatis Tartuensis, 7*(Supplement), 71-74.

Doğan, İ., Işik, Ö., & Ersöz, Y. (2016). Examining the Turkish men's professional basketball team's success according to game-related statistics with discriminant analysis. *International Journal of Performance Analysis in Sport*, *16*(3), 829-836. doi: 10.1080/24748668.2016.11868931

Ergül, B. (2014). Classification of NBA league teams using discriminant and logistic regression analyses. *Pamukkale Journal of Sport Sciences*, *5*(1), 48-60.

García, J., Ibáñez, S. J., Martinez De Santos, R., Leite, N., & Sampaio, J. (2013). Identifying basketball performance indicators in regular season and playoff games. *Journal of Human Kinetics,* 36(1), 161-168. doi: 10.2478/hukin-2013-0016

Gimenez, J., & Janeira, M. (2003). Game statistics discriminating the final outcome of junior world basketball championship matches (Portugal 1999). *Journal of Human Movement Studies*, 45, 1-19.

Glazier, P. S. (2017). Towards a grand unified theory of sports performance. *Human movement science*, *56*, 139-156. doi:10.1016/j.humov.2015.08.001

Gómez, A.M., Lorenzo, A., Sampaio, J., José Ibáñez, S., & Ortega, E. (2008). Game-related statistics that discriminated winning and losing teams from the Spanish men's professional basketball teams. *Collegium Antropologicum*, *32*(2), 451-456.

http://www.euroleague.net/competition/teams (Accessed 09.03.2018).

Hughes, M., & Franks, I. M. (Eds.). (2004). *Notational analysis of sport: Systems for better coaching and performance in sport*. London, UK: Routledge

Ibáñez, S. J., Sampaio, J., Feu, S., Lorenzo, A., Gómez, M. A., & Ortega, E. (2008). Basketball game-related statistics that discriminate between teams' season-long success. *European journal of sport science*, *8*(6), 369-372. doi: 10.1080/17461390802261470

Ittenbach, R. F., & Esters, I. G. (1995). Utility of team indices for predicting end of season ranking in two national polls. *Journal of Sport Behavior*, *18*(3), 216-224.

Kozar, B., Vaughn, R. E., Whitfield, K. E., Lord, R. H., & Dye, B. (1994). Importance of free-throws at various stages of basketball games. *Perceptual and Motor skills*, *78*(1), 243-248.

Lorenzo Calvo, A., Gómez Ruano, M. Á., Ortega Toro, E., Ibañez Godoy, S. J., & Sampaio, J. (2010). Game related statistics which discriminate between winning and losing under-16 male basketball games. *Journal of Sports Science and Medicine*, 9(4), 664-668.

Marmarinos, C., Apostolidis, N., Kostopoulos, N., & Apostolidis, A. (2016). Efficacy of the "pick and roll" offense in top level European basketball teams. *Journal of human kinetics*, *51*(1), 121-129. doi:10.1515/hukin-2015-0176

Özdamar, K. (2013). *Paket Programlar ile İstatistiksel Veri Analizi.* Eskişehir, TR: Nisan Kitabevi.

Pojskić, H., Šeparović, V., & Užičanin, E. (2009). Differences between successful and unsuccessful basketball teams on the final Olympic tournament. *Acta Kinesiologica*, *3*(2), 110-114.

Ribas, R. L., Navarro, R., Tavares, F., & Gómez, M. A. (2011). Analysis of number of players involved in rebound situations in Euroleague basketball games. *Open Sports Sciences Journal*, *4*, 10-13.

Sampaio, J., Godoy, S.I., & Feu, S. (2004). Discriminative power of basketball game related statistics by level of competition and sex. *Perceptual and Motor Skills*, 99, 1231-1238. doi: 10.2466/pms.99.3f.1231-1238

Sampaio, J., Janeira, M., Ibanez, S., & Lorenzo, A. (2006). Discriminant analysis of game-related statistics between basketball guards, forwards and centres in three professional leagues. *European Journal of Sport Science*, 6(3), 173-178. doi:10.1080/17461390600676200

Sampaio, J., Lago, C., & Drinkwater, E. J. (2010a). Explanations for the United States of America's dominance in basketball at the Beijing Olympic Games (2008). *Journal of Sports Sciences*, 28(2), 147-152. doi: 10.1080/02640410903380486

Sampaio, J., Drinkwater, E. J., & Leite, N. M. (2010b). Effects of season period, team quality, and playing time on basketball players' game-related statistics. *European Journal of Sport Science*, 10(2), 141-149. doi: 10.1080/17461390903311935

Severini, T. A. (2014). Analytic methods in sports: Using mathematics and statistics to understand data from baseball, football, basketball, and other sports. Chapman and Hall/CRC.

Tabachnick, B. G., & Fidell, L. S. (2001). *Computer-assisted research design and analysis.* Allyn & Bacon, Boston.

Taxildaris, K., Papadimitriou, K., Alexopoulos, P., Fatouros, I. G., Kambas, A., Karipidis, A., ... & Barbas, I. (2001). Factors characterizing the offensive game of the playmaker position in basketball. *Journal of Human Movement Studies*, *40*(6), 405-421.

DOI 10.26773/mjssm.190307

ORIGINAL SCIENTIFIC PAPER

The Effects of Weekly Recreational Soccer Intervention on the Physical Fitness Level of Sedentary Young Men

Alper Aslan[1], Yasar Salci[1], Alpay Guvenc[2]

Affiliations: [1]Hatay Mustafa Kemal University, School of Physical Education and Sports, Coaching Education, Hatay, Turkey, [2]Antalya Akdeniz University, Faculty of Sports Sciences, Coaching Education, Antalya, Turkey

Correspondence: A. Aslan, Hatay Mustafa Kemal University, School of Physical Education and Sports, Coaching Education, Akıncılar, 31001 Alahan/Antakya/Hatay, Turkey. E-mail: alperaslan72@gmail.com

ABSTRACT Recreational soccer (RS) has a great potential to improve the physical fitness levels of diverse populations when performed two to three times per week. However, to date, only Beato and collaborators have examined the effects of once-a-week RS on physical fitness, even though this frequency is widespread among participants. Thus, this study aimed to investigate the effect of weekly performed RS intervention on components of physical fitness in sedentary young men. Twenty-healthy men aged 20-27 years were randomly assigned to a soccer (n=10) group or a control (n=10) group. Participants in the soccer group played a 60-min. small-sided soccer game once-a-week for eight weeks. Before and after the intervention period, body composition, aerobic fitness, blood pressure, anaerobic performance and isokinetic leg strength were assessed. After eight weeks of the once-a-week intervention period, in the soccer group, body fat and thickness of skinfolds were significantly decreased ($p<0.05$). Peak oxygen uptake, running distance, squat and countermovement jump ($p<0.01$), concentric quadriceps and eccentric hamstring strength were also improved only in the soccer group ($p<0.05$). In contrast, other variables, including body mass (BM), body mass index (BMI), fat-free mass (FFM), heart rate responses, blood pressure, and anaerobic performance remained the same as before the intervention period ($p>0.05$). Participating in weekly RS programme can lead to some health and performance benefits. However, the people who wish to further improve their health status and performance level should increase the frequency of RS activity.

KEY WORDS health, body composition, aerobic endurance, strength, heart rate

@MJSSMontenegro
EFFECTS OF WEEKLY RECREATIONAL SOCCER INTERVENTION
http://mjssm.me/?sekcija=article&artid=173

Introduction

It is well established that physical activity is related to decreased risk of several chronic diseases, improved physical capacity, and increased quality of life. Therefore, physicians focus on promoting regular physical activity habits that will be retained throughout the lifespans of their patients. In this context, RS has a great potential to improve the health and physical fitness levels of diverse populations. This may because the dynamic nature of soccer not only provides opportunities to develop different aspects of physical fitness of participants, but it also contains positive motivational and social factors that contribute to the maintenance of a physically active lifestyle (Andersen et al., 2010).

Multiple studies of diverse populations have demonstrated that average cardiovascular load during RS exceeded 80% heart rate (HR) maximum even in elderly individuals (Randers et al., 2010b; Randers et al., 2012; Aslan, 2013). Moreover, a recent study demonstrated that during RS 20-30% of total time spend with an HR above 90% of the maximal HR (Randers et al., 2010b). Furthermore, RS is an intermittent activity including many high-intensity actions (sprinting, turns, jumping, kicking, accelerations, and decelerations) the would be expected to stimulate positive adaptations in several physical fitness parameters. However, the number of training sessions or weekly training volume and the length of the intervention period are also the most

Received: September 27 2018 | Accepted after revision: November 18 2018 | First published online: March 01 2019

Conflict of interest: None declared.

vital components to achieve morphological and physiological adaptations. In recent studies, it was demonstrated that 12 weeks of soccer practice performed three 60 min sessions per week improved maximal aerobic power, jumping performance, flexibility, and body composition parameters in healthy untrained young males (Milanovic, Pantelic, Kostic, Trajkovic, & Sporis, 2015b; Milanovic, Pantelic, Sporis, Mohr, & Krustrup, 2015c).

Similarly, Randers et al. (2012) demonstrated that 12 weeks of soccer games three days per week increased the physical fitness level and cardiovascular health status of middle-aged homeless men, represented by VO_2max, incremental cycle test performance, fat percentage, and LDL cholesterol. Krustrup et al. (2010a) also reported similar findings in a study of untrained men when the small-sided RS was performed two to three times per week for 12 weeks. There is also experimental evidence for the effectiveness of RS in the improvement of the physical fitness of different population groups, including premenopausal women (Krustrup et al.,2010b) mild to moderate hypertensive middle-aged men (Andersen et al., 2010) and prepubertal children (Krustrup et al., 2014) when the activity was performed two to three days a week.

In contrast, a lack of time is one of the most commonly reported barriers to exercise participation (Gibala, Little, MacDonald, & Hawley, 2012). Therefore, this may be the reason that a single RS session a week is as common or even more common among participants. A recent study demonstrated that a single RS session a week accounted for 50% of the ACSM-recommended lowest level of energy expenditure (Beato, Impellizzeri, Coratella, & Schena, 2016). However, to our knowledge, there is only one study investigating the effect of a single RS session a week on physical fitness levels (Beato, Coratella, Schena, & Impellizzeri, 2017) and there is still a great deal of uncertainty about the threshold activity levels that can enhance health and performance level of young individuals (Hiruntrakul, Nanagara, Emasithi, & Borer, 2010). The time-efficient threshold theory proposes that intensity coupled with minimal frequency and duration of training may provide the requisite stimulus (Winett & Carpinelli, 2000). Therefore, the purpose of this study was to investigate the effects of weekly performed RS intervention on the components of physical fitness in young sedentary males.

Methods

Participants and Procedure

Twenty sedentary healthy men not previously involved in any systematic training participated in this study. Participants were randomly assigned either to a soccer group [n=10, age 22.1±1.8 years, height 172.6±4.4cm, BM 70.8±3.9kg] or to a control group [n=10, age 23.4±1.6 years, height 173.9±4.7cm, BM 72.4±4.7kg]. Participants in the soccer group played a one-hour small-sided soccer game once-a-week for eight weeks on a 30-50-metre artificial grass pitch (excluding goalkeepers, each team comprised five players), whereas participants in the control group continued their routine daily life. During the games, HR responses were recorded with a sampling frequency of 5 s using a Polar HR monitor (RS800 CX, Polar Electro, Finland) to determine the game intensity throughout the intervention period. Then intensity was quantified as the mean percentage of HR reserve (%HRres). %HRres was calculated according to the formula of Karvonen (1957). [(%HRres=(match mean HR-resting HR)/(HRmax-resting HR)x100]. Before and after the eight weeks of intervention, the following tests were administered to all participants on separate days in the following order: I) resting HR, systolic blood pressure (SBP) and diastolic blood pressures (DBP), anthropometric measurements, squat jump (SJ) and countermovement jump (CMJ) tests, II) Wingate anaerobic test (WAnT), III) isokinetic leg strength test, IV) the maximal multistage 20-m shuttle run test (SRT). The last three tests were conducted at least one day apart from each other to allow for adequate recovery. All of these tests were completed within the one-week period in the same order, before the beginning of the intervention (pre-test) and after the completion of the eight weeks intervention period (post-test). All tests were conducted under indoor conditions at the same time of day, and the participants were familiar with these test procedures before actual testing. All subjects were instructed to abstain from eating for at least two hours before the tests. In addition, they were asked to maintain their nutritional habits and daily lifestyle throughout the intervention protocol. The average temperature and humidity during the pre-test were 18.2±1.7˚C and 63.7±4.18%, respectively (Hanna Instruments, HI 8564, Italy). Corresponding values during the post-test were 21.3±1.3˚C and 67.1±2.57%, respectively. The study received ethical approval from the human ethics committee of local university (2013/07), and informed consent was obtained from all participants.

Anthropometric Measurements

Height and BM were measured using a calibrated electronic scale (Seca, France) to the nearest 0.1cm and 0.1kg, respectively, with the subject lightly dressed without shoes. BMI was calculated as BM (kg) divided by height (m^2). The thickness of eight skinfolds (biceps, triceps, subscapular, chest, suprailiac, abdominal, thigh and medial calf) was measured with a skinfold calliper (Holtain Ltd, UK) to the nearest 0.2 mm, on the right side of the body, using standard procedures (Lohman & Roche, 1988). The sum of the eight skinfolds was used as a total indicator of fatness. Alternatively, the sums of arm, trunk, and leg skinfolds were also used as a regional indicator of fatness. Moreover, the percentage of body fat (%BF) was calculated from the Faulkner equation (Faulkner, 1968). Fat-free mass (FFM) was calculated from %BF and BM. One investigator performed all measurements to avoid any inter-observer differences.

DOI 10.26773/mjssm.190308

Determination of Resting Heart Rate and Blood Pressures

Resting HR was recorded for 10 minutes in a supine position using HR monitor (RS800 CX, Polar Electro, Finland). Thereafter, the minimum HR observed during this period was used as the resting HR value (Dellal et al., 2012). SBP and DBP were measured three times on the left arm at the level of the heart (Omron Healthcare Co. Ltd, Kyoto, Japan). All the measurements were completed in the morning at 8:00–10:00 am. The SBP and DBP were determined as the average of three recordings in mmHg. The mean arterial blood pressure (MAP) was calculated by the following formula: [(SBP–DBP)/3+DBP] (Elliott, Sale, & Cable, 2002).

Squat and Counter Movement Jump Tests

Before the tests, each subject performed a standardized warm-up protocol. SJ and CMJ performances were measured using an electronic timing mat (Ergo Tester, Italy). SJ was performed from a half squatting position with hands placed on hips. The participants were asked to remain motionless for 2 s, and then they jumped vertically for maximal height. The participants were not allowed to countermovement at the start of the jump. CMJ was administered while the participants started from an erect standing position. Then, they made a downward countermovement to the same starting position as the SJ and jumped vertically for maximum height. All participants performed three consecutive trials, and the highest value for each jump was used.

Wingate Anaerobic Test

The WAnT was performed on a computerized cycle-ergometer (Monark 834E, Sweden). Before the test, each subject was informed about the protocol. The seat height was adjusted for each subject, and the feet were strapped to the pedals. After a standardized 3-min warm-up, the subject rested for 5 min (Inbar, Bar-Or, & Skinner, 1996). The subject was instructed to perform the test as fast as possible. Then the WAnT was initiated against minimal resistance. Following 3-4 seconds, the predetermined resistance (75 gr.kg^{-1}) was applied, and the computer was activated. Verbal encouragement was given throughout the 30-s test. After the test, the subject was instructed to pedal slowly to assist recovery. The highest and the lowest power output obtained in the 30-s were defined as peak and minimum power, respectively, and the mean power was the average of all values obtained during the test. A fatigue index was also calculated (Inbar et al., 1996). Power outputs were expressed in absolute (W) and relative units (W·kg^{-1}).

Isokinetic Leg Strength Test

Isokinetic strength data were recorded with the Biodex System-4 Dynamometer (Biodex Medical Inc, Shirley, NY) to assess the strength of the muscle groups in accordance with the Biodex System manual (Biodex Multi-Joint System Pro, 2017). Strength measurements were preceded by a five-minute standardized warm-up on a cycle ergometer at 80W. Each subject then performed lower extremity flexibility exercises, including quadriceps, hamstring, and calf stretches. Every stretching exercise was performed three times and held for 15 s. Subjects were tested for both concentric and eccentric quadriceps (Q_{con} & Q_{ecc}) and hamstring (H_{con} & H_{ecc}) strength on dominant legs at 60°/s. The dominant leg was defined as the preferred kicking leg. The testing criteria consisted of three maximal concentric and eccentric efforts; meanwhile, three submaximal knee extension and flexion contractions were allowed before the real tests. A 3 min. rest was allowed for between each test. Peak torque (PT), PT to body weight (PT/BW), conventional (H_{con}/Q_{con}) and dynamic control (H_{ecc}/Q_{con}) ratios were chosen for strength analysis.

Maximal Multistage 20-m Shuttle Run Test

Aerobic fitness was assessed using SRT according to the one-min protocol (Leger, Mercier, Gadoury, & Lambert, 1998). During the SRT, HR was recorded continuously every 5-s period with a Polar HR monitoring system. Peak HR was determined for each subject as the highest HR recorded during any 5-s period of the SRT. Moreover, HR responses to submaximal running speeds were also calculated for each subject. At the end of the SRT, the total number of completed shuttles was recorded for each subject. Thereafter, the peak oxygen uptake (VO_2peak) was calculated from the following formula: [VO_2peak=61.1-(0.462 × age)-(0.862 x BMI)+(0.192 × number of shuttles completed)] (Matsuzaka et al., 2004). In addition, peak running distance (RDpeak) (i.e., number of completed shuttles multiplied by 20-m) during the SRT was also calculated for each subject and used in the further analysis.

Statistical Analysis

All data were presented as mean value ± standard deviation (sd). The assumption of normality and homogeneity of variance were verified using the Kolmogorov-Smirnov and Hartley's F_{max} test, respectively. The data were analyzed with separate 2×2 (groups and time) mixed repeated-measures ANOVA design. The SPSS's syntax language was used to analyse the simple effect of time within levels of group variable. All statistical analysis was performed using SPSS for Windows, version 15.0 (SPSS Inc., Chicago, USA). The level of statistical significance was set at $p<0.05$ for all analyses.

Results

The mean intensity of the soccer small-sided games was 172.7±1.9 b.min^{-1} (within the range of 169.6 to175.1 b.min^{-1}), which corresponded to 80.6±4.3% of the HRres (Figure 1).

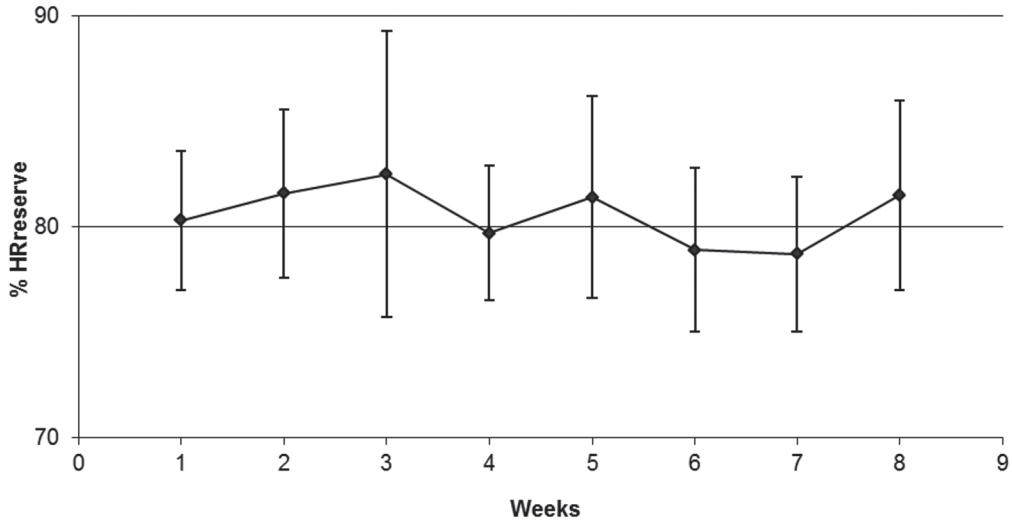


FIGURE 1 Game intensity throughout the 8-weeks of intervention period

There was no significant difference in all parameters between the soccer and the control group before the intervention period (Table 1 and Table 2). After the weekly intervention period, % BF ($F_{1,18}$=4.784, p<0.05), the sum of eight skinfolds ($F_{1,18}$=4.667, p<0.05) and arm skinfolds ($F_{1,18}$=8.742, p<0.01) were significantly reduced in the soccer group, but unchanged in the control group (Table 1). Moreover, BM, BMI, FFM, sum of the trunk and leg skinfolds, resting HR and MAP values also tended to reduce after the intervention period in the soccer group, but the differences were not statistically significant (p>0.05) (Table 1).

TABLE 1 Body composition, blood pressures, heart rate and aerobic endurance variables before and after the 8 weeks of weekly intervention in the soccer and control groups. Data are presented as means ± sd

	Soccer Group		Control Group	
	Pre-test	**Post-test**	**Pre-test**	**Post-test**
Body mass (kg)	70.8±3.9	69.8±4.4	72.4±4.7	73.1±5.5
BMI (kg/m²)	23.8±1.3	23.4±1.4	24.0±1.5	24.2±1.7
Body fat (%)	13.2±2.1	12.5±1.9*	12.7±2.3	12.5±2.4
FFM (kg)	61.4±2.3	61.0±2.9	63.2±3.2	63.8±3.6
ΣS (mm)	81.4±19.4	74.8±18.4*	79.7±24.5	78.5±27.6
TrunkΣS (mm)	50.4±15.5	46.3±14.2	47.0±16.0	45.8±17.3
ArmΣS (mm)	12.6±2.2	11.2±2.2**	12.2±3.1	12.4±4.3
LegΣS (mm)	18.4±4.5	17.3±4.1	20.5±6.8	20.3±7.8
DBP (mmHg)	75.0±2.9	73.6±3.2	73.8±3.1	72.8±3.7
SBP (mmHg)	118.7±7.4	116.4±7.9	116.6±7.3	114.1±6.8
MAP (mmHg)	89.6±3.1	85.7±2.4	88.1±4.3	86.5±3.5
Resting HR (b.min^{-1})	66.0±6.2	64.2±5.9	65.7±6.5	66.50±7.3
HR at 9 km.h^{-1} (b.min^{-1})	161.4±6.6	158.2±5.7	164.7±5.8	162.9±4.8
HR at 10 km.h^{-1} (b.min^{-1})	177.0±5.5	173.8±2.3	175.6±5.6	176.3±5.4
HR at 11 km.h^{-1} (b.min^{-1})	186.2±6.3	183.6±3.8	184.2±4.5	184.9±5.5
HR at 12 km.h^{-1} (b.min^{-1})	193.4±5.3	191.9±5.4	190.3±4.3	191.1±4.6
HRpeak (b.min^{-1})	199.2±3.7	199.5±4.9	198.5±2.8	198.2±4.3
RDpeak (m)	1757.8±108.4	2046.7±162.5#	1772.0±253.4	1812.0±232.5
VO_2peak (mL.kg^{-1}.min^{-1})	47.4±1.9	50.4±2.6#	46.7±2.5	46.9±2.3

Note. *significantly lower than pre-test value at p<0.05, **significantly lower than pre-test value at p<0.01, #significantly higher than pre-test value at p<0.001, BMI: body mass index, FFM: fat free mass, ΣS: sum of the eight skinfolds (biceps, triceps, subscapular, chest, suprailliac, abdominal, thigh, medial calf), TrunkΣS: sum of the trunk skinfolds (subscapular, chest, suprailiac, abdominal), ArmΣS: sum of the arm skinfolds (biceps, triceps), LegΣS: sum of the leg skinfolds (thigh, medial calf), DBP: diastolic blood pressure, SBP: systolic blood pressure, MAP: mean arterial blood pressure, HR: heart rate, RDpeak: peak running distance during shuttle run test, VO_2peak: estimated peak oxygen consumption from shuttle run test.

Relative to the control group, the soccer group showed a significant improvement in their endurance capacity on the SRT following the weekly intervention period (Table 1). After eight weeks of match-play, in the soccer group, VO2peak ($F_{1,18}$=21.743, p<0.001) and RDpeak ($F_{1,18}$=15.354, p<0.001) increased by 6.3% and 16.4%,

DOI 10.26773/mjssm.190308

respectively, whereas in the control group no significant changes were observed in VO2peak or RDpeak (p>0.05). Moreover, submaximal HR responses also showed a slight tendency to decrease after the intervention period in the soccer group (Table 1), though not significantly (p>0.05).

The soccer group showed a significant improvement in its SJ ($F_{1,18}$=8.493, p<0.01) and CMJ ($F_{1,18}$=8.089, p<0.05) performance following the weekly intervention period (Table 2). After eight weeks of match-play, in the soccer group, SJ and CMJ heights increased by 9.5% and 9.1%, respectively, whereas in the control group no significant changes were observed in jump heights. Furthermore, peak and minimum power outputs also showed a slight tendency to increase after the intervention period in the soccer group (Table 2), though not significantly (p>0.05).

TABLE 2 Anaerobic performance variables and isokinetic strength ratios before and after the 8 weeks of weekly intervention in the soccer and control groups. Data are presented as means ± sd

	Soccer Group		Control Group	
	Pre	**Post**	**Pre**	**Post**
Absolute peak power (W)	561.1±68.2	577.9±60.6	614.1±77.6	609.5±54.7
Relative peak power (W.kg^{-1})	7.96±1.1	8.28±0.8	8.51±1.1	8.44±0.7
Absolute mean power (W)	416.9±30.5	411.9±24.9	430.4±31.5	436.3±38.2
Relative mean power (W.kg^{-1})	5.90±0.5	5.91±0.5	5.96±0.31	6.03±0.3
Absolute min. power (W)	295.0±24.2	304.9±19.5	312.6±37.5	298.3±34.2
Relative min. power (W.kg^{-1})	4.19±0.5	4.38±0.3	4.32±0.3	4.12±0.4
Fatigue index (%)	46.6±8.7	46.7±6.5	48.4±8.4	50.7±7.1
SJ (cm)	47.6±3.2	52.1±4.2 **	47.8±3.7	48.5±4.0
CMJ (cm)	49.5±3.4	54.0±3.9 *	49.7±3.8	50.8±4.5
H_{con}/Q_{con} Ratio	56.87±5.8	56.61±6.1	53.99±5.7	57.21±3.4
H_{ecc}/Q_{con} Ratio	0.78±0.1	0.79±0.1	0.80±0.1	0.75±0.1

Note. *significantly higher than pre-test value at p<0.05, **significantly higher than pre-test value at p<0.01, SJ: squat jump, CMJ: countermovement jump, H_{con}/Q_{con}: concentric hamstring/quadriceps, H_{ecc}/Q_{con}: eccentric hamstring/concentric quadriceps.

The results indicated that after the training period Q_{con} PT ($F_{1,18}$=5.512, p<0.05) and PT/BW ($F_{1,18}$=5.846, p<0.05) and H_{ecc} PT ($F_{1,18}$=4.588, p<0.05) and PT/BW ($F_{1,18}$=6.064, p<0.05) values increased in the soccer group, but no changes were observed in the control group (Figure 2). Furthermore, conventional and dynamic strength control ratios remained the same after eight weeks of interventions in both groups (p>0.05) (Table 2).

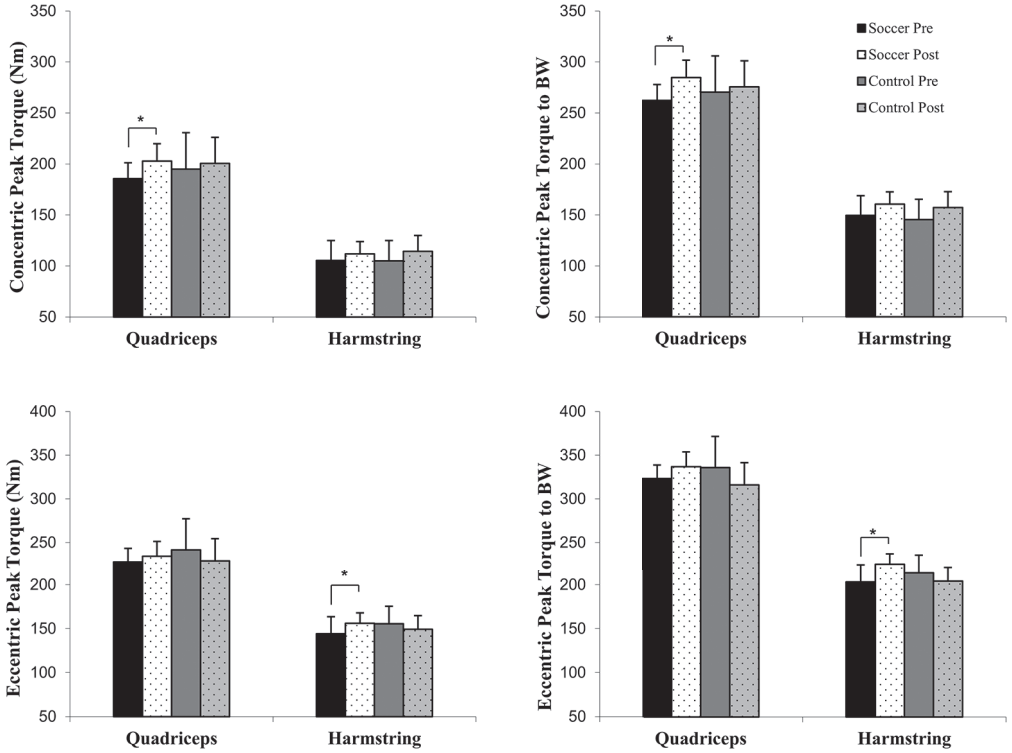


FIGURE 2 Weekly recreational soccer intervention induced changes in isokinetic strength performance over 8 weeks

Note. *significantly higher than pre-test values at p<0.05

Discussion

This study examined whether once-a-week RS for eight weeks influenced the physical fitness status of sedentary young men. To our knowledge, only one previous study (Beato et al., 2017) has examined the effect of a single one-hour RS intervention a week on the level of physical fitness. However, while Beato et al. (2017) examined the effects of RS on health-related physical fitness components in middle-aged males, the present study focuses on both health- and performance-related physical fitness components in young males. Thus, the main contribution of this study concerning the existing literature is that it provides information about whether the components of health- and performance-related physical fitness of young sedentary individuals are influenced by such a low frequency of soccer activity. The main findings revealed that although eight weeks of one-hour weekly small-sided RS resulted in the improvement of several physical fitness components, including %BF, aerobic endurance, and muscular strength in sedentary young men, it could not produce sufficient stimulus on resting and submaximal HR responses and blood pressure, which can be considered as an important indicator of cardiovascular health status. In addition, the current study indicated that weekly RS intervention over eight weeks failed to improve anaerobic energy turnover.

A recent review and meta-analysis indicated that small-sided RS with training frequency of two to three sessions per week positively affects aerobic fitness level regardless of the age, sex and health status of the participants (Hammami et al., 2016; Milanovic, Pantelic, Covic, Sporis, & Krustrup, 2015a). Krustrupt et al. (2009), in a study conducted on healthy untrained males, indicated that VO_2max improved 7% after two to three weekly one-hour small-sided RS sessions over four weeks, and additional improvements were observed from 4 to 12 weeks. Thus, it can be suggested that the effectiveness of RS on aerobic endurance begins early in the intervention period. Similarly, the present study indicated that there were 16.4% and 6.3% increases in RDpeak during the SRT and estimated VO_2peak, respectively. Similar to the present findings, Beato et al. (2017) reported 4.4% and 5.95% increase in VO_2max and maximal aerobic speed, respectively, after 12 weeks of weekly performed RS in middle-aged males. These findings recommended that RS is an effective activity to improve aerobic endurance level of participants even performed only once a week. Unfortunately, oxygen consumption could not be determined directly in this study. However, enhanced maximal oxygen consumption may be a plausible suggestion for the increase in aerobic endurance. In fact, the activity profile during small-sided RS is similar to interval training, which is proven to be an effective method for VO_2max improvement (Milanovic, Sporis, & Weston, 2015d). Notably, high-intensity periods during RS (time spend over 90% HRmax) elicits greater improvement in VO_2max compared with aerobic running (Krustrup et al., 2009). The effectiveness of RS on aerobic fitness was also indicated by Randers et al. (2010a) who observed that VO_2max can be maintained over a long time even though the training frequency reduced from 2.4 to 1.3 sessions per week.

It was demonstrated that the untrained males participating in the soccer training programme, two to three times weekly for 12 weeks, each lasting 60 min, had a decrease in resting HR and HR during submaximal continuous running. In addition, in the same study, it was observed that regular soccer training resulted in 8 and 5 mmHg drops of SBP and DBP, respectively. Similar observations were made by Anderson et al. (2010) and Randers et al (2010a) in untrained males when RS was performed two to three weekly over 12 weeks. Beato et al. (2017) also indicated beneficial effects of RS on SBP and MAP performed only once a week. In contrast, the present results showed no-significant decrease in either blood pressure or HR responses at rest and during submaximal exercise after the intervention period. However, the observed decrease of 3.9 mmHg (89.6 vs 85.7) in MAP in this study is in accordance with the findings of Beato et al. (2017) and Randers et al. (2010a) who indicated 3 mmHg and 5 mmHg drops in MAP, respectively, over 12 weeks of football training in untrained males.

In contrast, the extents to which values can be changed by training depend on subjects' levels before the initiation of the training programme. In this study, before the initiation of the intervention period, the SBP, DBP, and resting HR values of our participants were within the normal range or at somewhat lower level (Table 1), which may attenuate the adaptation process. Cornelissen and Fagard (2005), in a random effects model meta-analysis study, indicated that the reduction of SBP and DBP were higher in hypertensive study groups compared with normotensive study groups. Similarly, Krustrup et al. (2009) observed that the reduction of resting blood pressure was more pronounced in the seven subjects with the highest initial values. Randers et al. (2012) also indicated that although blood pressure was unaltered after 12 weeks of street soccer (2.2 per week), DBP was lowered for all participants with previous values greater than 75 mmHg. Therefore, future studies may be needed to further examine the effectiveness of weekly RS intervention on blood pressure and HR responses in different populations, especially including those who are hypertensive and who have initially high resting HR values.

According to the present results, the sum of eight skinfolds and %BF only slightly decreased in the soccer group after the intervention period, but no significant changes were observed in BM, BMI, or FFM. In agreement with the present results, a recent study demonstrated that once-a-week 1 h performed RS would not produce substantial and significant improvements in body weight, %BF, and BMI in middle-aged males (Beato et al., 2017). The findings of these two studies can be interpreted as once a week RS intervention is not a proper strategy when the major aim of participants is to reduce body weight and % BF. However, a previous study conducted on young adult men revealed that 12 weeks of three 60 min soccer sessions per week led

DOI 10.26773/mjssm.190308

to considerable decrease on BM, BMI, and %BF (Milanovic et al., 2015b). Similarly, a recent meta-analysis concluded that two weekly 60 min RS interventions lasting 12-16 weeks are likely to cause a decrease in total fat mass of 1-3 kg (Milanovic et al., 2018). In addition, it was demonstrated that RS intervention can increase lean body mass when performed two to three times weekly over 12 weeks in untrained males and females (Krustrup et al., 2009; Krustrup et al., 2010a; Krustrup et al., 2010b). Therefore, it seems that the effect of RS activity on body composition is unsurprisingly related to the frequency of weekly sessions/total volume and length of the intervention period.

Previous studies investigating the effectiveness of RS on the neuromuscular system showed that this type of activity potentially increases muscular strength when the exercise is performed two to three times weekly over 12 weeks, or for longer periods of time (Krustrup et al., 2009; Krustrup et al., 2010a; Krustrup et al., 2010b). In a study of young men participating in RS two to three times a week over 12 weeks, Krustrup et al. (2010a) observed a significant increase in the quadriceps muscle mass, mean fibre area, lean body mass as well as maximal isometric hamstring strength. Moreover, a recent meta-analysis indicated a positive effect of RS on muscular fitness evaluated as jump performance (Milanovic et al., 2018). Similarly, according to the present results, the soccer group increased their Q_{con}, H_{ecc} strength and jumping performances after the intervention period. Indeed, the soccer practice involves intermittent physical activity and variety of skills requiring running, sprinting, jumping and kicking. All these activity patterns are the quadriceps-dominant activities while the hamstring plays an important role in the stability of the knee joint complex (Fried & Lloyd, 1992). Furthermore, the hamstring muscles contract eccentrically during soccer activities, such as kicking, sprinting or changing of directions, in order to decelerate the forward movement of the leg. Therefore, improvements in Q_{con} and H_{ecc} strength could be explained by the contraction characteristics of muscle groups during soccer activities. However, because of the lack of increase in FFM observed in this study, it is more likely that the strength gains may associate with an increase in neural recruitment rather than muscular hypertrophy.

The present results also showed that conventional and functional strength ratio evaluations did not differ after an eight-week intervention period. The conventional ratio has been claimed to be one of the many variables that contribute to knee joint stability and control (Aagaard, Simonsen, Magnusson, Larson, & Dyhre-Poulsen, 1998; Kellis & Baltzopoulus, 1998). The practical significance of the functional ratio is related with the functional tasks (i.e., vertical jump) or dynamic knee joint movements (Coombs & Garbutt, 2002). Although there were significant increases in Q_{con} and H_{ecc} strength after the intervention period, the symmetric strength improvement repressed the development of the functional strength ratio. In this study, it is also apparent that symmetric strength gains functionally resulted in significant improvement in vertical jump performances (Table 2). These findings indicated that weekly soccer practice also had a beneficial effect on functional movement tasks. However, the amount of increase in jumping performance observed in this study (9.1-9.5%, for CMJ and SJ, respectively) is lower compared to that in the study of Milanovic et al. (2015c). (12.1-14.8% for CMJ and SJ, respectively) where training performed three times a week for 12 weeks.

In conclusion, once-a-week RS interventions over eight weeks positively influenced the physical fitness level of sedentary young men by lowering % BF and increasing aerobic endurance, jumping performance, Q_{con} and H_{ecc} strengths. In contrast, it could not produce sufficient stimulus to decrease resting and submaximal HR, blood pressures, anaerobic performance, Q_{ecc} and H_{con} strengths. However, the participants of this study were already physically fit healthy young subjects and the intervention duration somewhat lower than the previous studies. Therefore, remarkable initial values in combination with a relatively short intervention period might resulted in an attenuated adaptation response. Nonetheless, even though the present findings recommended that RS performed once a week provides substantial improvement in aerobic endurance and leg strength parameters, the participants who wish to further improve their health and performance levels should increase the weekly frequency of RS activity. Since the magnitude of adaptations can be influenced by several factors, including age, gender, and health status (Milanovic et al., 2018), the findings of this study cannot easily be extended to other populations. Therefore, future studies are needed to examine the health and performance effects of single RS a week in a diverse population.

REFERENCES

Aagaard, P., Simonsen, E. B., Magnusson, S. P., Larsson, B., & Dyhre-Poulsen, P. (1998). A new concept for isokinetic hamstring: quadriceps muscle strength ratio. *The American journal of Sports Medicine*, 26(2), 231-237. doi: org/10.1177/03635465980260021201

Andersen, L. J., Randers, M. B., Westh, K., Martone, D., Hansen, P. R., Junge, A., ... & Krustrup, P. (2010). Football as a treatment for hypertension in untrained 30–55-year-old men: a prospective randomized study. *Scandinavian Journal of Medicine & Science in Sports*, 20, 98-102. doi: org/10.1111/j.1600-0838.2010.01109.x

Aslan, A. (2013). Cardiovascular responses, perceived exertion and technical actions during small-sided recreational soccer: Effects of pitch size and number of players. *Journal of Human Kinetics*, 38, 95-105. doi: org/10.2478/hukin-2013-0049

Beato, M., Impellizzeri, F. M., Coratella, G., & Schena, F. (2016). Quantification of energy expenditure of recreational football. *Journal of Sports Sciences*, 34(24), 2185-2188. doi: org/10.1080/02640414.2016.1167280

Beato, M., Coratella, G., Schena, F., & Impellizzeri, F. M. (2017). Effects of recreational football performed

once a week (1 h per 12 weeks) on cardiovascular risk factors in middle-aged sedentary men. *Science and Medicine in Football*, 1(2), 171-177. doi: org/10.1080/24733938.2017.1325966

Biodex Multi-Joint System Pro (2017). Setup/Operation Manual. Retrieved 07/02, 2017, from: http://www.biodex.com

Coombs, R., & Garbutt, G. (2002). Developments in the use of the hamstring/quadriceps ratio for the assessment of muscle balance. *Journal of Sports Science & Medicine*, 1(3), 56-62.

Cornelissen, V. A., & Fagard, R. H. (2005). Effects of endurance training on blood pressure, blood pressure–regulating mechanisms, and cardiovascular risk factors. *Hypertension*, 46(4), 667-675. doi: 10.1161/01.HYP.0000184225.05629.51

Dellal, A., Owen, A., Wong, D. P., Krustrup, P., van Exsel, M., & Mallo, J. (2012). Technical and physical demands of small vs. large sided games in relation to playing position in elite soccer. *Human Movement Science*, 31(4), 957-969. doi: org/10.1016/j.humov.2011.08.013

Elliott, K. J., Sale, C., & Cable, N. T. (2002). Effects of resistance training and detraining on muscle strength and blood lipid profiles in postmenopausal women. *British Journal of Sports Medicine*, 36(5), 340-344. doi: org/10.1136/bjsm.36.5.340

Faulkner, J. A. (1968). Physiology of swimming and diving. In F. H. (Ed.), Exercise physiology. Baltimore: Academic Press.

Frıed, T., & Lloyd, G. J. (1992). An overview of common soccer injuries, management and prevention. *Sports Medicine*, 14, 269-275. doi: org/10.2165/00007256-199214040-00005

Gibala, M. J., Little, J. P., MacDonald, M. J., & Hawley, J. A. (2012). Physiological adaptations to low-volume, high-intensity interval training in health and disease. *The Journal of Physiology*, 590(5), 1077-1084. doi: org/10.1113/jphysiol.2011.224725

Hammami, A., Chamari, K., Slimani, M., Shephard, R. J., Yousfi, N., Tabka, Z., & Bouhlel, E. (2016). Effects of recreational soccer on physical fitness and health indices in sedentary healthy and unhealthy subjects. *Biology of Sport*, 33(2), 127-137. doi: 10.5604/20831862.1198209

Hiruntrakul, A., Nanagara, R., Emasithi, A., & Borer, K. T. (2011). Effect of once a week endurance exercise on fitness status in sedentary subjects. *Journal of the Medical Association of Thailand*, 93(9), 1070-1074.

Inbar, O., Bar-Or, O., Skinner, J. S. (1996). The Wingate Anaerobic Test. Human Kinetics, Champaign, IL.

Karvonen, M. J. (1957). The effects of training on heart rate: a longitudinal study. *Ann Med Exp Biol Fenn*, 35, 307-315.

Kellis, E., & Baltzopoulos, V. (1998). Muscle activation differences between eccentric and concentric isokinetic exercise. *Medicine and Science in Sports and Exercise*, 30(11), 1616-1623. doi: 10.1097/00005768-199811000-00010

Krustrup, P., Nielsen, J. J., Krustrup, B., Christensen, J. F., Pedersen, H., Randers, M. B., ...& Bangsbo, J. (2009). Recreational soccer is an effective health promoting activity for untrained men. *British Journal of Sports Medicine*, 43, 825-831. doi: org/10.1136/bjsm.2008.053124

Krustrup, P., Christensen, J. F., Randers, M. B., Pedersen, H., Sundstrup, E., Jakobsen, M. D., ... & Bangsbo, J. (2010a). Muscle adaptations and performance enhancements of soccer training for untrained men. *European Journal of Applied Physiology*, 108(6), 1247-1258. doi: org/10.1007/s00421-009-1319-8

Krustrup, P., Hansen, P. R., Andersen, L. J., Jakobsen, M. D., Sundstrup, E., Randers, M. B., ... & Junge, A. (2010b). Long-term musculoskeletal and cardiac health effects of recreational football and running for premenopausal women. *Scandinavian Journal of Medicine & Science in Sports*, 20, 58-71. doi: org/10.1111/j.1600-0838.2010.01111.x

Krustrup, P., Hansen, P. R., Nielsen, C. M., Larsen, M. N., Randers, M. B., Manniche, V., ... & Bangsbo, J. (2014). Structural and functional cardiac adaptations to a 10-week school-based football intervention for 9–10-year-old children. *Scandinavian Journal of Medicine & Science in Sports*, 24, 4-9. doi: org/10.1111/sms.12277

Leger, L. A., Mercier, D., Gadoury, C., & Lambert, J. (1988). The multistage 20 metre shuttle run test for aerobic fitness. *Journal of Sports Sciences*, 6(2), 93-101. doi: org/10.1080/02640418808729800

Lohman, T. G., & Roche, A. F. (1988). Anthropometric standardization reference manual (Vol. 177, pp. 3-8). R. Martorell (Ed.). Champaign: Human kinetics books.

Matsuzaka, A., Takahashi, Y., Yamazoe, M., Kumakura, N., Ikeda, A., Wilk, B., & Bar-Or, O. (2004). Validity of the multistage 20-m shuttle-run test for Japanese children, adolescents, and adults. *Pediatric Exercise Science*, 16(2), 113-125. doi: org/10.1123/pes.16.2.113

Milanovic, Z., Pantelic, S., Covic, N., Sporis, G., Krustrup, P. (2015a). Is recreational soccer effective for improving VO_2max? A systematic review and meta-analysis. *Sports Medicine*, 45(9), 1339-1353. doi: org/10.1007/s40279-015-0361-4

Milanović, Z., Pantelić, S., Kostić, R., Trajković, N., & Sporiš, G. (2015b). Soccer vs. running training effects in young adult men: which programme is more effective in improvement of body composition? Randomized controlled trial. *Biology of Sport*, 32(4), 301-305. doi: 10.5604/20831862.1163693

Milanović, Z., Pantelić, S., Sporiš, G., Mohr, M., & Krustrup, P. (2015c). Health-related physical fitness in healthy untrained men: effects on VO2max, jump performance and flexibility of soccer and moderate-intensity continuous running. *PloS one*, 10(8), e0135319. doi: org/10.1371/journal.pone.0135319

Milanović, Z., Sporiš, G., & Weston, M. (2015d). Effectiveness of high-intensity interval training (HIT) and continuous endurance training for VO 2max improvements: a systematic review and meta-analysis of

 DOI 10.26773/mjssm.190308

controlled trials. *Sports Medicine*, 45(10), 1469-1481. doi: org/10.1007/s40279-015-0365-0

Milanović, Z., Pantelić, S., Čović, N., Sporiš, G., Mohr, M., & Krustrup, P. (2018). Broad-spectrum physical fitness benefits of recreational football: a systematic review and meta-analysis. *British Journal of Sports Medicine*, 43,825-831. doi: 10.1136/bjsports-2017-097885

Randers, M. B., Nielsen, J. J., Krustrup, B. R., Sundstrup, E., Jakobsen, M. D., Nybo, L., ... & Krustrup, P. (2010a). Positive performance and health effects of a football training program over 12 weeks can be maintained over a 1-year period with reduced training frequency. *Scandinavian Journal of Medicine & Science in Sports*, 20, 80-89. doi: org/10.1111/j.1600-0838.2010.01091.x

Randers, M. B., Nybo, L., Petersen, J., Nielsen, J. J., Christiansen, L., Bendiksen, M., ... & Krustrup, P. (2010b). Activity profile and physiological response to football training for untrained males and females, elderly and youngsters: influence of the number of players. *Scandinavian Journal of Medicine & Science in Sports*, 20, 14-23. doi: org/10.1111/j.1600-0838.2010.01069.x

Randers, M. B., Petersen, J., Andersen, L. J., Krustrup, B. R., Hornstrup, T., Nielsen, J. J., ... & Krustrup, P. (2012). Short-term street soccer improves fitness and cardiovascular health status of homeless men. *European Journal of Applied Physiology*, 112(6), 2097-2106. doi: org/10.1007/s00421-011-2171-1

Winett, R. A., & Carpinelli, R. N. (2000). Examining the validity of exercise guidelines for the prevention of morbidity and all-cause mortality. *Annals of Behavioral Medicine*, 22(3), 237-245. doi: org/10.1007/BF02895119

ORIGINAL SCIENTIFIC PAPER

Connection in the Fresh Air: A Study on the Benefits of Participation in an Electronic Tracking Outdoor Gym Exercise Programme

Urban Johnson[1], Andreas Ivarsson[1], James Parker[1,2], Mark B. Andersen[1], Ingrid Svetoft[2]

Affiliations: [1]Halmstad University, Center of Research on Welfare, Health and Sport, Halmstad, Sweden, [2]Halmstad University, School of Business, Engineering and Science, Halmstad, Sweden

Correspondence: U. Johnson, Centre for Research on Welfare, Health and Sport, Halmstad University, Sweden, Box 823, S-301 18 Halmstad, Sweden. E-mail: urban.johnson@hh.se

ABSTRACT This study aimed to explore whether a six-week intervention, based on participation in outdoor exercise, including activity-tracking devices and combined with individual consulting sessions, can both increase physical activity and yield positive changes in physiological and psychological health measures. A total of six participants, with a mean age of 41.2 (range 33-50 years), completed the ten-week study and the six-week intervention. The full study consisted of a four-week control/baseline and a six-week intervention period in which each participant acted as their own controls. Continuous measures of physical activity data were collected using a wrist-worn activity sensor during the ten-week study, along with pre- and post-measures of cardiovascular fitness, upper-body strength, BMI, general health, and motivation to exercise. The intervention consisted of a resistance-training programme for an outdoor gym and three motivational interviewing sessions. Effect sizes (percentage) for changes pre- to post-training were calculated. The results, because of the small sample size, are presented as individual cases, but the group, as a whole, showed average increases from baseline (pre-) to post-measures in strength (maximum row; 15.33%), time to exhaustion (3.58%), number of steps per day (4%), and autonomous motivation (12%) and average decreases in body weight (-1.08%), fat percentage (-7.58%), strength (chest; -2.5%), and stress symptoms (-2.17%). The six-week intervention programme showed promising results regarding physical activity changes. This study contributes to the limited evidence of the impact of resistance training programmes using outdoor gyms, electronic tracker, and motivational interviewing on physical activity outcomes.

KEY WORDS physical activity, physiological health, psychological well-being, computerized exercise intervention, motivational interviewing

Introduction

Healthy living is associated with positive levels of several different variables, such as psychological and social well-being, physiological and metabolic health, physical capacity as well as cognitive functioning (Godfrey et al., 2013). Physical activity is one key factor to improve global public health, and evidence-based interventions to promote PA are, therefore, of central importance. Research has shown that outdoor environmental exercise interventions result in an overall increase in PA (Tester & Baker, 2009) and access to outdoor exercise equipment has been found to help increase activity levels in people who do not usually exercise (Kelly & Fry, 2011). Supportive urban planning (e.g., free public access to outdoor gym equipment) has the potential to facilitate PA, well-being, and health, and modern health technology can have critical potentiating effects (Pratt et al., 2012). New innovative designs using modern health technology (e.g., PA and sleep-monitoring apps for smartphones) applied to outdoor exercise might attract new users and promote sustainable health behaviours within communities (Shane, Lowe, & Ólaighin, 2014).

Environmental factors' have the potential to influence PA, and research has highlighted the importance of promoting functional facilities designed for exercise (Kahn et al., 2002). In the literature, a number of

Received: October 19 2018 | Accepted after revision: November 29 2018 | First published online: March 01 2019

Conflict of interest: None declared.

potentially effective facilities have been listed (e.g., outdoor fitness equipment; Chow, 2013) and using environmental applications (e.g., outdoor fitness equipment accessible to the public) as tools to facilitate PA that may be effective because they have the potential to reach a wide variety of people. Technological advances have a similar potential to positively influence PA, and the use of activity-tracking devices has been found to increase PA motivation (Bice, Ball, & McClaran, 2016). Two recent systematic reviews have demonstrated that the use of accelerometers (Goode et al., 2017) and smartphones (Bort-Roig, Gilson, Puig-Ribera, Contreras, & Trost, 2014) has small and modest positive effects on PA and weight loss, respectively, among adults, but more research is needed to investigate the motivational influence of popular commercial activity monitors.

One framework frequently used to understand behavioural as well as social factors and their influences on exercise motivation is the self-determination theory (SDT; Deci & Ryan, 2004). SDT places emphasis on the social context and its ability to facilitate or thwart optimal motivation and on the extent to which behaviours are generally self-determined or externally controlled. In SDT, it is suggested that self-determined motivation and psychological well-being will be promoted when certain basic psychological needs (autonomy, competence, relatedness) are satisfied in PA/exercise settings, and interventions nourishing these needs will not only increase self-determined motivation towards exercise programmes, but also adherence to such programmes (Ng et al., 2012; Teixeira, Carraca, Markland, Silva, & Ryan, 2012). One approach that has been effective to support behaviour change is motivational interviewing (MI; Breckon, 2015). MI targets the three key components in self-determination theory, and this approach has been found to be effective in terms of behaviour change (Hardcastle, Taylor, Bailey, Harley, & Hagger, 2013).

Given the current state of research into accessible outdoor exercise equipment, a systematic evaluation of the effects of participation in outdoor gym exercise programmes, supported by information technology and motivational interviewing is warranted. To our knowledge, few studies have combined physical and psychological strategies within the same intervention, using an innovative mixture of modern health technology applications, activity trackers, and motivational interviewing in an outdoor environment among a healthy but physically inactive population. This study aims to explore if a six-week intervention, based on participation in outdoor exercise sessions, using activity-tracking devices and combined with individual MI sessions, can help increase physical activity. An additional aim was to investigate if participation in the intervention was associated with changes in physiological as well as psychological health measures.

Methods

Participants and inclusion criteria

Altogether six participants, working within the Halmstad, Sweden municipality, were selected for the study (male = 4; female = 2) with a mean age of 41.2 (*SD* = 6.5); men 42.5 (*SD* = 6.6) and women 38.5 (*SD* = 7.8). The selection of the participants was based on voluntary choice and with the support of the Halmstad City Council. The inclusion criteria used in the selection of the participants were: (a) having a primarily sedentary job; (b) limited exercise activity in the past year; and (c) employed within Halmstad's City Council, which is relatively close to the outdoor gym.

Psychological measurements

The General Health Questionnaire–12 (GHQ-12) (Goldberg, Gater, & Sartorius et al., 1997) is intended to measure psychological distress/well-being and assesses three dimensions: (a) positive well-being (e.g., Have you recently been able to concentrate on whatever you're doing?), (b) anxiety (e.g., Have you recently lost much sleep due to worry?), and (c) loss of confidence (e.g., Have you recently been losing confidence in yourself?). The responses are recorded on a 4-point Likert-type scale ranging from 0 (*I don't agree at all*) to 3 (*I totally agree*) with a Cronbach alpha ranging from 0.83 to 0.93.

Motivation was measured using the Behavioral Regulation in Exercise Questionnaire-2 (BREQ-2) (Markland, & Tobin, 2004), which contains19 items (e.g., It's important to me to exercise regularly) measured on a five-point Likert scale ranging between 0 (*not true for me*) to 4 (*very true for me*). The scale measures behavioural regulations through five motivation factors: amotivation, external, introjected, identified, and intrinsic motivation and the five-factor model indicated an adequate fit for measuring exercise motivation. Based on recommendations from Sebire and colleagues (2008), we created one autonomous motivation factor (identified regulation and intrinsic regulation). This factor was used in all analyses.

Physiological measurements

Body composition measurements of body mass index (BMI) and total body fat mass were measured with an eight-polar tactile-electrode impedance meter (bioelectrical impedance analysis InBody 770, Biospace Ltd, Seoul, Korea). Bioimpedance analysis has been shown to be a valid tool, in comparison to dual-energy X-ray absorptiometry, for measuring total body-fat mass (ICC female= 0.97, ICC male=0.93) in the general middle-aged population (Ling et al., 2011). In should be noted that bioimpedance analysis may overestimate body-fat by 8% when compared to dual-energy X-ray absorptiometry. All body composition measurements were performed early in the morning, and each participant abstained from eating and drinking coffee for at least six hours prior to the testing. The modified Bruce Treadmill Test (Noon & Dean, 2000) (time to exhaustion) was used to measure cardiovascular fitness, and muscular strength was assessed using a one-repetition maximum strength test (Levinger et al., 2007). All strength testing was performed using commercial resistance machines (Atlantis

DOI 10.26773/mjssm.190309

Inc. Quebec, Canada). The exercises selected to assess one-repetition maximum were a chest press (PWP3010 plate-loaded vertical chest press), a shoulder press (Atlantis performance converging shoulder press PE-149), and a seated row (Atlantis performance diverging row PE-137). Due to the similarity of exercise movement and muscle groups used during the chest press and shoulder press, the change in muscular strength for the exercises was very similar; for this reason, we have chosen to only present the results from the chest press.

Instrument

Physical activity data were collected with a wrist-worn activity sensor (based on Apple Watch and iPhone) that collects information about each day's activities (steps taken). All participants were given one of these wristbands at the start of the study. Data were first stored locally on the smartphone and then downloaded from the Health Data App on the smartphones using the QS Access application. Apple Watch, iPhone 6, and the Health Data app have been reported to better validity (ICC=0.89) in comparison to five other commercially available devices for measuring the total amount of daily steps (Noon & Dean, 2000); furthermore, the consistency of total steps by different devices of the Apple Watch Series 1 have been reported as very high (r=0.99) (Wen, Zhang, Liu, & Lei, 2017). A specific web-port0061l (Quick Search) was used to collect the psychometric data.

Exercise intervention

The participants took part in an intervention aimed to increase PA. Exercise behaviours were supported through individual motivational interviewing coaching sessions and a resistance-training programme designed for use in an outdoor gym. The individual motivational interviewing coaching sessions were composed of four processes (Breckon, 2015). In the *engaging* processes, an establishing of connection and a therapeutic relationship was established. After that, the process of *focusing* was developed to maintain a detailed direction in the conversation about change to support exercise behaviour. The next process was *evoking*, which involved the participants own motivation for change. The last process was *planning*, which involved both developing commitments to change and formulating an action plan. The sessions took place between Week 8 (after four weeks of preparation and four weeks of baseline and at the start of the interventions) and Week 14 (see Table 1). When the intervention started, the participants were introduced to the outdoor gym and instructed how to use it (an instructor was present at the start of the intervention for each participant). During their exercise, it was possible for the participants to access direct feedback on their physical activities at the gym (e.g., heart rate, calories burned, session duration).

TABLE 1 Time plan for the study

Week/s	Working issue
0	First meeting with participants, information about the study, ethics
4	Distribution of smartwatches (pre-test,) physical tests and psychological questionnaires (1)
4-8	Pre-test/base-line and control period
8	Introduction to outdoor gym, 1st motivational interviewing (MI) session, 2nd psychological questionnaires
8-14	Interventions period
14	Physical tests, second MI session and third psychological questionnaires

Description of the outdoor gym

The outdoor gym consists of four stationary machines and two modules for free exercises. These are row, shoulder-press, chest-press, squat (stationary machines), as well as lunge and jumping jacks (free modules). The stationary machines have a variety of resistance levels by way of a weight plate system, which allowed the participants to select the resistance they wanted. A two-metre-high post stands at the centre of the gym (see Figure 1) and acts as a timing device. Participants selected one of two training sessions, either the 20:10 s (work: rest) or the 40:20 s (work: rest) session by pressing a button on the post. Once a session was selected, LEDs inside the post glow either green or red to indicate a work period (green) or rest (red) period. The surface of the outdoor gym

FIGURE 1 Outdoor exercise setting at Slottsparken, Halmstad, Sweden

consists of tempered rubber in colour tones in harmony with the surrounding city park and local architecture (see Figure 1). Situated in the centre of a park with frequently used walkways, the outdoor gym is meant to invite (perhaps inspire) citizens to use it.

Procedures

Table 1 outlines the time plan for the study procedures from the first contact with the participants until the final testing session 14 weeks later. The first four weeks were dedicated to contacting participants and distributing the wrist-worn activity sensor. Baseline measures were taken during Week 5 and up to Week 8. The intervention started in Week 8. At this point participants were instructed to complete the exercises at the outdoor gym approximately two times a week (Table 2) and, if possible, in connection with their regular work schedule (e.g., during lunchtime). Motivational interviewing occurred at Weeks 8 and 14. Ethical approval for the study was granted by the regional ethics committee (reference number 2016/843).

TABLE 2 Typical training schedule for the 8-week intervention

Week	Session 1	Session 2
8	2 rounds of 20:10	2 rounds of 20:10
9	3 rounds of 40:20	3 rounds of 40:20
10	4 round of 40:20	3 rounds of 40:20
11		4 rounds of 20:10
12	3 rounds of 40:20	3 rounds of 40:20
13	4 rounds of 40:20	3 rounds of 40:20
14	4 rounds of 0:20	4 rounds of 40:20

Note. 1 round= 1 set on each of the six stations at the outdoor gym, 20:10 = 20s work and 10s rest, 40:20 = 40s work and 20s rest

Data analysis

To analyse how participation in the intervention programme influenced PA motivation and exercise behaviours, we used percentages as the magnitude indices. More specifically, percentages were used to illustrate potential changes in the psychological, behavioural, and physiological measures between the baseline (pre) and Week 14 (post) measurements. These calculations were performed for each participant. The results for each variable for each participant were then summed and averaged for an overall percentage for the full sample. The results, however, are described in detail for each participant.

Results

The overall results showed an average increase from baseline to the post measures in strength (row; 15.33%), time to exhaustion (3.58%), steps (4%), and autonomous motivation (12%). The overall results also showed

TABLE 3 Cases and effect size pre-post measures (percentage)

Participants	A	B	C	D	E	F
Activity wrist-band						
Steps (SD) Pre	8250 (3800)	8440 (2420)	8980 (2920)	11100 (4190)	9920 (5502)	9190 (3400)
Steps (SD) Post	8980 (4050)	9470 (3540)	9010 (3940)	11310 (4200)	10300 (2770)	9320 (3980)
Change in steps (%)	9%	12%	0.5%	2%	4%	1.5%
Difference between Avg. Steps for Age and Gender Pre	-500	-1500	-1000	1010	1300	-800
Difference between Avg. Steps for Age and Gender Post	230	-470	-970	1220	1680	-670
Impedance meter						
Body-weight (kg) Pre/Post	89/89.1	115/111	93.9/95.2	97.6/97.2	72.4/72	103.4/100.6
BMI Pre/Post (kg/m^2)	28.4/28.4	34.4/33.2	25.7/26.1	30.8/30.7	25.3/25.2	29.6/28.8
Change body-weight (%)	0%	-3.5%	1%	-0.5%	-0.5%	-3%
Fat (kg) Pre/Post	32/29.5	42.8/38.2	13.9/13.3	27.2/25.7	23.2/22.6	28.3/24.3
Change fat mass (%)	-8%	-11%	-4.5%	-5.5%	-2.5%	-14%
Bruce treadmill test						
Time to exhaustion (minutes) Pre/Post	17:00/17:30	15:10/15:38	20:39/20:45	16:12/18:01	16:40/16:48	16:27/17:20
Change in time to exhaustion (%)	2%	2%	0%	11.5%	0.5%	5.5%
Days without logging any activity. (Between test 1 & 2)	0	0	6	1	0	0
Strength tests						
Change in Chest (%)	0%	10.5%	-18%	18%	-8%	-14.5%
Change in Seated row (%)	13.5%	21%	10%	14.5%	27%	7%
Psychological questionnaire						
Change in autonomous motivation. BREQ-2 Pre/Post (%)	1.75/2.13 (21%)	2.0/2.83 (41%)	2.88/2.70 (-6%)	2.0/2.63 (31%)	2.88/2.55 (-11%)	3.0/2.88 (-4%)
Change in stress symptoms, GHQ-12 Pre/Post (%)	2.66/2.16 (-19%)	2.0/1.66 (-17%)	1.66/1.16 (-30%)	1.33/1.16 (-13%)	2.0/2.16 (8%)	1.16/1.83 (58%)

DOI 10.26773/mjssm.190309

a decrease from baseline to the post measures in body weight (-1.08%), body fat (-7.58%), strength (chest; -2.5%), and stress symptoms (-2.17%). There was a consistent direction of effects for all participants in the change of body fat, strength (row), and time to exhaustion. In all other measures, the results showed mixed directions of the effects (see Table 3 for a comprehensive overview).

Discussion

Increases in the number of steps between pre- and post- measurement together with decreases in body fat and improved physical strength in the rowing test all indicate that the six-week exercise intervention period resulted in benefits, ultimately influencing physiological and psychological well-being in positive ways. Similar results have been shown in a recent meta-analysis, evaluating the effects of short-term exercise interventions for patients with chronic heart failure (Zhang et al., 2016).

One potential explanation for the increase in PA might be the use of activity-tracking devices to reinforce autonomous motivation for outdoor activity. The use of such devices may have stimulated the participants to take part in exercise activities (Bice, Ball, & McClaran, 2016). More specifically, applying self-monitoring to track personal improvement as well as achieving challenging goals has been suggested to be related to increased levels of autonomous motivation for PA (Kruger, Carlson, & Kohl, 2007). Also, studies have found that the use of activity trackers can foster behaviour change via increased levels of basic psychological needs, (Nurmi, Hagger, Haukkala, Araújo-Soares, & Hankonen, 2016). The fulfilment of these three needs is, as previously mentioned, related to increased levels of autonomous motivation.

Another potential explanation for the increased levels of PA might be that the participants took part in the individual motivational interviewing (MI) coaching sessions. Previous studies have shown that MI can strengthen a person's self-reliance for behaviour change (Hardcastle, Taylor, Bailey, Harley, & Hagger, 2013) to increased PA**.** Also, in this case, the potential mechanisms for the link between MI and PA might be increased levels of the basic psychological needs as well as autonomous motivation.

Still another potential explanation for the increase in PA during the intervention period is the location of the gym. The pleasant surroundings that frame the exercise setting (a green park) and the closeness to the city centre and workplaces may have also indirectly increased motivation to exercise and helped the participants to overcome potential barriers to PA and exercise such as limited opportunities for training and time constraints.

Despite the current study's inclusion criteria, of a sedentary job and low levels of PA, our cases showed varying levels of physiological health. Regardless of participants' starting health status, the short-term exercise intervention seems to have had positive physiological and psychological outcomes. In this study, the observed effects on physiological and psychological well-being may be related to exercise decreasing psychological stress symptoms. Perhaps the participants also had a feeling that the outdoor settings were restorative (Hug, Hartig, Hansmann, Seeland, & Hornung, 2009) and that the physical exercising represented opportunities for social interaction with other colleagues from their workplaces in a new and supportive environment. From an SDT perspective, social interaction at the outdoor gym may well have helped to support basic psychological needs such as competence and relatedness. The participants may have all selected a moderate intensity level relative to their current fitness status, and it could be that acute short-term effects of outdoor exercise have a positive influence on psychological well-being, regardless of initial fitness level. This line of reasoning receives partial support in a systematic review suggesting that public parks and green spaces have direct and positive influences on well-being (Bowler, Buyung-Ali, Knight, & Pullin, 2010).

Study limitations

One potential study limitation, in relation to SDT, is the possibility of other mechanisms (outside of motivation) contributing to change. Nevertheless, we have based our selection of motivation as one of our key variables because this variable, in previous studies of health behaviour change, has been found to be a central component. The current study used the number of steps as a measure for PA, but this measure does not account for total PA (such as cycling, swimming, and heavy lifting) and may underestimate total PA for some participants. Another limitation that might decrease the generalizability of the results is the small sample size, which arguably makes any conclusions regarding the predictive value of the measured variables hazardous. Clearly, the findings in the current study need to be replicated in new samples.

In contrast, the practical value of the research findings is very limited if clinically significant results only can be obtained when large numbers of participants are involved. Still another limitation relates to the selection of participants. Participants' starting physical capacity varied, which allowed some participants to improve their physical strength and endurance rather quickly, whereas improvements would be less pronounced for better physically trained participants. In follow-up studies, therefore, it is likely to be necessary to have more homogeneous groups in terms of strength and fitness. In addition, because of the voluntary choice of participants, a possible dose-response pattern is conceivable in relation to previous physical activity levels. The dose-response between volume and intensity could have a relation to our results; however, a recent systematic review and meta-analysis on the dose-response of walking on cardiovascular disease factors (including aerobic fitness and BMI) concluded that there is insufficient evidence to make any conclusions on dose-response relationships (Oja et al., 2018). One of the strengths of the study is the combination of both physical and psychological measurements, allowing a multifactorial assessment of the intervention programme and the usefulness of the results.

Conclusions
The results of the six-week intervention programme showed promising outcomes regarding PA increases in an outdoor gym setting. More specifically, most of the participants showed improved levels on both PA as well as physiological and psychological measures after the intervention. The study contributes to the limited evidence of the impact of resistance training programmes using outdoor gyms and motivational interviewing on physical activity outcomes.

Funding/support
The study was financed by a grant from The Knowledge Foundation, Sweden [Grant number 20160097].

Acknowledgements
The authors are particularly grateful to Erik Blomberg and Camilla Schough at Eleiko Sport AB, Sweden, Erik Viberg, Anton Bärwald and Pelle Wiberg at Swedish Adrenaline, Sweden, and Sofia Warpman at Halmstad Municipality, Sweden for helping to make the research project possible.

REFERENCES
Bice, M.R., Ball, J.W., & McClaran, S. (2016). Technology and physical activity motivation. *International Journal of Sport & Exercise Psycholology,* 14, 295-304. doi:10.1080/1612197X.2015.1025811

Bort-Roig, J., Gilson, N.D., Puig-Ribera, A., Contreras, R.S., & Trost, S.G. (2014). Measuring and influencing physical activity with smartphone technology: A systematic review. *Sports Medicine,* 44, 671–686. doi:10.1007/s40279-014-0142-5

Bowler, D.E., Buyung-Ali, L.M., Knight, T.M., & Pullin, A.S. (2010). A systematic review of evidence for the added benefits to health of exposure to natural environments. *BMC Public Health,* 10, 456. doi:10.1186/1471-2458-10-456

Breckon, J. (2015). Motivational interviewing, exercise, and nutrition counseling. In: M.B., Andersen, S.J., Hanrahan (Eds.) *Doing Exercise Psychology* (pp. 75-100). Champaign, IL: Human Kinetics.

Chow, H. (2016). Outdoor fitness equipment in parks: a qualitative study from older adults' perceptions. *BMC Public Health,*13:e1216. doi:10.1186/1471-2458-13-1216

Deci, E.L., & Ryan, R.M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry,* 4, 227-268. doi:10.1207/S15327965PLI1104_01

Lara, J., Godfrey, A., Evans E, Heaven, B., Brown, J.E., Barron, E.,… Mathers, J.C. (2013). Towards measurement of the healthy ageing phenotype in lifestyle-based intervention studies. *Maturitas, 76,* 189-199. doi:10.1016/j.maturitas.2013.07.007

Goldberg, D.P., Gater, R., Sartorius, N., Sartorius, N., Ustun, T. B., Piccinelli, M., Gureje, O.,…Rutter, C. (1997). The validity of two versions of the GHQ in the WHO study of mental illness in general health care. *Psychological Medicine,* 27,191-197. doi:10.1017/S0033291796004242

Goode, A.P., Hall, K.S., Batch, B.C., Huffman, K. M., Hastings, S. N., Allen, K. D.,…Gierisch, J. M. (2017).The impact of interventions that integrate accelerometers on physical activity and weight loss: A systematic review. *Annals of Behavioral Medicine,* 51, 79–93. doi:10.1007/s12160-016-9829-1

Hardcastle, S.J., Taylor, A.H., Bailey, M.P., Harley, R.S., & Hagger, M.S. (2013). Effectiveness of a motivational interviewing intervention on weight loss, physical activity and cardiovascular disease risk factors: a randomized controlled trail with a 12-month post-intervention follow-up. *International Journal of Behavioral Nutrition and Physical Activity,* 10, e40. doi:10.1186/1479-5868-10-40

Hug, S.M., Hartig, T., Hansmann, R., Seeland, K., & Hornung, R. (2009). Restorative qualities of indoor and outdoor exercise settings as predictors of exercise frequency. *Health & Place,*15, 971-980. doi:10.1016/j.healthplace.2009.03.002

Kahn, E.B., Ramsey, L.T., Brownson R.C., Heath, G.W., Howze, E.H., Powell, K.E.,…Corso, P. (2002). The effectiveness of interventions to increase physical activity. *American Journal of Preventive Medicine,* 22, 73-107. doi.org/10.1016/S0749-3797(02)00434-8

Kelly, B., & Fry, J. (2011). Camden outdoor gyms evaluation: Phase 1 [pdf]. London: NHS Camden. Available from http://www.camdendata.info/

Kruger, J., Carlson, S.A., & Kohl, H.W. (2007). Fitness facilities for adults: Differences in perceived access and usage. *American Journal of Preventive Medicine,* 32, 500-505. doi:10.1016/j.amepre.2007.02.003

Lara, J., Godfrey A., Evans E., Heaven, B., Brown, L. J., Barron, E.,…Mathers, J. C. (2013). Towards measurement of the healthy ageing phenotype in lifestyle-based intervention studies. *Maturitas,* 7(6), 189-199. doi:10.1016/j.maturitas.2013.07.007

Levinger, I., Goodman, C., Hare, D., Jerums, G., Toi, D., & Selig, S. (2007). The reliability of the 1RM test for untrained middle-aged individuals. *Journal of Science and Medicine in Sport,* 12, 310-316. doi:10.1016/j.jsams.2007.10.007

Ling, C.H.Y., de Craen, A. J.M., Slagboom, P.E., Gunn, D.A., Stokkel, M.P.M.,Westendorp, R.G.J.,…Maier, A.B. (2011). Accuracy of direct segmental multi-frequency bioimpedance analysis in the assessment of total body and segmental body composition in middle-aged adult population. *Clinical Nutrition*, 30, 610-615. doi:10.1016/j.clnu.2011.04.001

Markland, D., & Tobin, V. (2004). A modification to the Behavioral Regulation in Exercise Questionnaire to

 DOI 10.26773/mjssm.190309

include an assessment of amotivation. *Journal of Sport & Exercise Psychology,* 26, 191-196. doi:10.1123/jsep.26.2.191

Ng, J.Y.Y., Ntoumanis, N., Thogersen-Ntoumani, C., Deci, E.L., Ryan, R.M., Duda, J.L., & Williams, G.C. (2012). Self-determination theory applied to health contexts: A meta-analysis. *Perspectives on Psychological Science,* 7, 325-340. doi:19.1177/175691612447309

Noon, V., & Dean, E. (2008). Submaximal exercise testing: Clinical application and interpretation. *Physical Therapy,* 80, 782-807. doi:10.1093/ptj/80.8.782

Nurmi, J., Hagger, M.S., Haukkala, A., Araújo-Soares, V., Hankonen, N. (2016). Relations between autonomous motivation and leisure-time physical activity participation: The mediating role of self-regulation techniques. *Journal of Sport & Exercise Psychology,* 38, 128-137. doi:10.1123/jsep.2015-0222

Oja, P., Kelly, P., Murtagh, E., Murphy, M., Foster, C., & Titze, S. (2018). Effects of Frequency, intensity, duration and volume of walking interventions on CVD risk factors: a systematic review and meta-regression analysis of randomized controlled trials among inactive healthy adults. *British Journal of Sports Medicine,* 52, 769-755. doi:10.1136/bjsports-2017-098558

Pratt, M., Sarmiento, O.L., Montes, F., Ogilvie, D., Marcus, B.H., Perez, L.G.,…Brownson, R.C. (2012). The implications of megatrends in information and communication technology and transportation for changes in global physical activity. Lancet Physical Activity Series Working Group. *Lancet,* 380, 282-293. doi:10.1016/S0140-6736(12)60736-3

Tester, J., & Baker, R. (2009). Making the playfields even: Evaluating the impact of an environmental intervention on park use and physical activity. *Prevention Medicine,* 48:316-320. doi:101016/j.ypmed.2009.01.010

Shane, A., Lowe, S.H., & Ólaighin, G. (2014). Monitoring human health behaviour in one's living environment: A technological review. *Medical Engineering & Physics,* 36, 147-168. doi:10.1016/j.medengphy.2013.11.010

Sebire, S.J., Standage, M., & Vansteenkiste, M. (2008). Development and validation of the goal content for exercise questionnaire. *Journal of Sport & Exercise Psychology,* 30(4), 353–77. doi:10.1123/jsep.30.4.353

Teixeira, P.J., Carraca, E.V., Markland, D., Silva, M.N., & Ryan, R.M. (2012). Exercise, physical activity, and self-determination theory: a systematic review. *International Journal of Behavioral Nutrition and Physical Activity,* 9, 78. doi:10.1186/1479-5868-9-78

Wen, D., Zhang, X., Liu, X., & Lei, J. (2017). Evaluating the consistency of current mainstream wearable devices in health monitoring: A comparison under free-living conditions. *Journal of Medicine and Internet Research,* 19(3), e68. doi:10.2196/jmir.6874

Zhang, Y., Lisheng, X., Yao, Y., Sun, Y., Zhang, J., & Fu, Q. (2016). Effects of short-term intervention on cardiovascular functions and quality of life of chronic heart failure patients: A meta-analysis. *Journal of Exercise Science & Fitness,* 14, 67-75. doi:10.1016/j.jesf.2016.08.00

ORIGINAL SCIENTIFIC PAPER

Regional Differences in Adult Body Height in Kosovo

Bojan Masanovic[1], Tonci Bavcevic[2], Ivan Prskalo[3]

Affiliations: [1]University of Montenegro, Faculty for Sport and Physical Education, Niksic, Montenegro, [2]University of Split, Faculty of Kinesiology, Split, Croatia, [3]University of Zagreb, Faculty of Teacher Education, Zagreb, Croatia

Correspondence: B. Masanovic, University of Montenegro, Faculty for Sport and Physical Education, Narodne omladine bb, 81400 Niksic, Montenegro. E-mail: bojanma@ucg.ac.me

ABSTRACT This study aimed to test average body heights in both the male and females of Kosovo, as well as the differences in heights of both sexes in relation to the Kosovo administrative regions. A total of 1623 subjects participated in the research: 830 boys and 793 girls all attending their final year of secondary school. The anthropometric measurements were taken for subjects of both sexes from five different administrative regions of Kosovo. The measurements of body heights were taken by trained measurers in conformity with the ISAK protocol. Means and standard deviations were calculated for ages and body heights, as were frequencies for the calculation of the density of very short and very tall subjects. The results indicated that the average height of the male population of Kosovo was 179.52±5.96 centimetres and of the female population 165.72±4.93 centimetres. These results classify both the male and female populations of Kosovo among the tallest in the world. Regarding the regional differences, some variations have been observed, and the differences in body heights among specific regions clearly confirm the assumption that the population living in the Dinaric Alps is taller in relation to the rest of the population, while the specific average height of the central region, where the capital city is located, reflects the expected situation conditioned by continuous migrations from all other parts of Kosovo, as well as the fact that there is a growing secular trend towards the territory of the capital city, due to better economic and living conditions.

KEY WORDS Standing Height; Stature; Local Differences; Kosovo

@MJSSMontenegro
ADULT HUMAN HEIGHT IN KOSOVO
http://mjssm.me/?sekcija=article&artid=175

Introduction

Researchers from Europe, the USA, and Japan were interested in trends in changes of body height in males, and the research was later extended to other regions throughout the world; the interest in the estimation of body height in males has a rather clear and long tradition, while the interest in body height in females has been recent (Popovic, 2018). Some were simply curious, and the others had practical reasons for research. In most societies, being tall was in a high correlation with positive attitudes as far as the acceptance of a group is concerned, above all because being taller has also meant being stronger, which was a significant factor in times of the turbulent history of development of humankind, contributing to survival (Popovic, 2018); these attitudes possibly remain on the territory of the region of the Western Balkans. Furthermore, being tall was also in a high correlation with the perception of being attractive and acceptable for the majority of conservative societies, especially in male populations, as the tendency was to compare a person's height in relation to members from his society and to praise him or her for being taller, implying more attractive, stronger, better, or similar.

Contemporary studies include increasing results on the average body height of modern nations; one of the most significant ones has been the research carried out by the NCD Risk Factor Collaboration (2016), particularly due to its sample, which included 1472 populations, 200 countries, and 18.6 million participants. The study showed results of the average height in adult males and females throughout the world in the 20th century. However, this study failed to include data on the average height of the population of Kosovo, a country

Received: November 30 2018 | Accepted after revision: December 30 2018 | First published online: March 01 2019

Conflict of interest: None declared.

not included in any study, representing a significant fact for the present research as it can be considered as an addition to the above-mentioned study.

Furthermore, unlike the majority of European countries and those from the region of the Western Balkans, on the territory of Kosovo, the data on the average body height has never been gathered, so every initiative regarding research in this area is significant for both kinesiological anthropology and anthropology in general. The body height of the population of Kosovo was analysed in the studies that investigated the relation of body height and the length of the foot (Popovic, Arifi, & Bjelica, 2017), as well as body height and arm span in Kosovo (Arifi et al., 2017), which can be used for determining the average height of Kosovans. However, a detailed analyses of the average height of the entire population, or even per administrative region has never been implemented before, which gives a special significance to this research, mostly due to the fact that the population of Kosovo, even though ethnic Albanians, show significantly higher values (almost 5 cm) of body height in comparison to their neighbouring Albanians (personal communication, J. Jarani). Especially since one part of Kosovo lies in the area of a mountain range known as the Dinaric Alps, it is essential to determine if the type of the terrain is the reason for this difference in the average height between the Kosovans and Albanians, or to determine if there was perhaps another reason, as the aim of this study is to analyse the average values of the body height in administrative regions of Kosovo.

It is interesting to start the analyses with the fact that the borders of Kosovo are mountain ranges that are surrounding the middle part of the country, situated on a lower sea level, and consisting of plains, hills and hillocks. In addition to this low-lying part, it is necessary to point out that a bigger part, gravitating towards the southern border of Kosovo that is not a part of the Dinaric Alps, is the area of the Sharr Mountains (Alb.: Sharr). Furthermore, from the most eastern part of the Sharr Mountains towards the north, there is a mountain range known as the Skopska Crna Gora (Alb.: Karadak). Moreover, towards the northern part of Kosovo, the mountains do not reach even a half of the height as those from the southern part up to the slopes of Kopaonik ranging from central Serbia. Also, at the western part of Kosovo, from Montenegro to Albania, there is another mountain range known as the Prokletije or the Albanian Alps (Alb.: Bjeshket e Nemura) that are a geological extension of the Dinaric Alps (Figure 1).

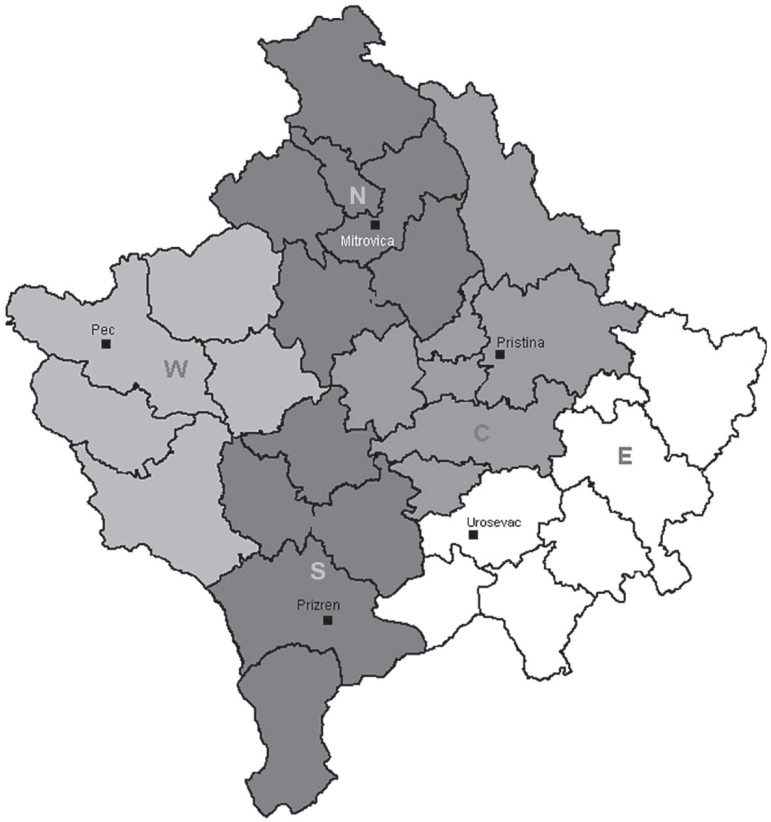


FIGURE 1 Administrative regions of Kosovo (Source: KFOR_Structur.2006, 2006)

It is important to introduce the terrain of Kosovo in order to make a clear division of the area between the mountain range of the Dinaric Alps and the other areas, especially due to a clear assumption that people living in the area of the Dinaric Alps are characterized by above average body height (Coon, 1939; Coon, 1970, Pineau, Delamarche, & Bozinovic, 2005). The best example is Kosovo, which is inhabited by one ethnic group in the Dinaric Alps slopes and in other mountain ranges, which makes it challenging for further analyses to obtain an answer to a decades-old question regarding whether the tallest people in the world live there. Therefore, the results of this research would provide clear knowledge on the existence of differences in body

DOI 10.26773/mjssm.190310

height regarding the administrative regions of Kosovo, and confirm whether the tallest people live in the area of the Dinaric Alps (Pineau et al., 2005). In contrast, it would be expected that the population is on average somewhat shorter in the central part of Kosovo, outside the range of the Dinaric Alps. Furthermore, the capital city of Pristina is a place where people from all the regions meet after decades of migration due to better living conditions; therefore, it cannot be taken into consideration as a factor for any fundamental analyses, so it will only be analysed descriptively.

FIGURE 2 Borders of Dinaric Alps mountain range (Source: Zoom into Dinaric Alps mountain range, 2017)

Learning the average values of body height is not only crucial for a potential "test of strength" among the subjects living in certain municipalities and regions of Kosovo, but also for experts in the fields of medicine and public health as they can aid in the estimation of current nutritional status and obesity (Popovic, Bjelica, Tanase, & Milasinovic, 2015), as well as for sports experts who can benefit from this information for early talent identification and orientation towards a sport that best suits the morphological characteristics of identified talented people (Grgantov et al., 2017; Masanovic, Milosevic, & Corluka, 2018; Stoop, Hohenauer, Rucker, & Clijsen, 2018). New research indicates that body height is connected to longevity and that tall mothers have less risk of unfavourable pregnancy outcomes. In addition, taller men and women have fewer health issues, such as cardiovascular and respiratory diseases, but they have a higher risk of some types of carcinoma (Quanjer et al., 2014; NCD Risk Factor Collaboration, 2016).

Therefore, this research has a multidisciplinary character, as it can be useful both to scholars from several fundamental and applied scientific fields, and applied in practice on the general population. Considering the lack of research in the area of Kosovo regarding body height, the authors of this study have conducted analyses on a sample that could represent the population of Kosovo on the representative level, analysing regional geographical differences, and determining the average values of body height according to the administrative region. Consequently, the basic aim of this study was to provide detailed analyses of regional geographical differences regarding the adult body height of both sexes and to obtain clear conclusions regarding the question of whether the population living in the Dinaric Alps is significantly taller than the population from the other mountain ranges or low-lying areas. It also aimed to provide the public with a rich database on the body height of males and females from all regions of Kosovo.

Methods

This study included a sample of 1623 final year students from five high schools from the administrative regions of Kosovo (northern, southern, eastern, western and central regions), divided into two subsamples: 830 male students (18.25±0.45) and 793 female students (18.24±0.43). This particular sample was selected because growth and development should be completed at this age. It is widely known that in this period there is no significant loss in body height due to different physiological reasons or external influences, which is the case for the older generations. In addition, it is important to emphasize that criteria for the selection of subjects for the sample were not having any physical deformity that might impact body height and having permanent residence on the territory of Kosovo.

The protocol of the International Society for the Advancement of Kinanthropometry (ISAK) was employed in ten secondary schools from Kosovo, including the municipalities of Decan, Ferizaj, Gjakova, Gjilan, Istog, Junik, Mitrovica, Peja, Pristina, and Prizren (Marfell-Jones, Olds, Stew, & Carter 2006), and the body height measurements were taken by trained measurers. The age of the study subjects was determined from the date of taking the measurement and their reported date of birth.

The average body height was calculated using the Statistical Package for the Social Sciences SPSS 23.0. Means, standard deviation, and the range of minimum and maximum values obtained from the measurements of body height are shown for both males and females from all five administrative regions of Kosovo, and for ten respective municipalities. The analyses also included the percentage of short (170 and 160 centimetres and lower) and tall people (190 and 200 centimetres and above).

Results

Analysis of the average body height of male subjects is shown in Table 1. The average body height of the overall sample of male subjects was 179.52±5.96 centimetres, while the tallest subjects live in the central region of Kosovo (180.62±5.88 cm), the medium ones in the northern region (180.29±5.72 cm), shorter ones in the western region (179.±5.88 cm), those shorter than them in the southern region (179.15±5.56 cm), and finally the shortest ones live in the eastern region (177.68±6.65 cm) of Kosovo.

TABLE 1 Descriptive statistics among male subjects

Municipality/Region	N	Age		Body height		
		Mean	SD	Mean	SD	Range
Deçan	85	18.14	0.35	179.66	6.30	166.8-196.4
Ferizaj	95	18.15	0.36	179.84	5.28	169.2-193.8
Gjakovë	61	18.33	0.47	180.49	6.40	168.7-196.0
Gjilan	90	18.26	0.24	177.68	6.65	161.4-191.1
Istog	56	18.29	0.46	180.15	6.37	163.5-195.4
Junik	45	18.24	0.48	177.75	5.37	167.6-188.2
Mitrovicë	87	18.25	0.46	180.29	5.72	167.9-197.3
Pejë	91	18.24	0.43	179.95	5.39	164.2-193.0
Prishtinë	100	18.26	0.44	180.62	5.88	170.3-198.8
Prizren	120	18.40	0.57	178.71	5.73	164.6-192.3
Northern Region	87	18.25	0.46	180.29	5.72	167.9-197.3
Western Region	232	18.26	0.46	179.89	5.95	163.5-196.4
Central Region	100	18.26	0.44	180.62	5.88	170.3-198.8
Eastern Region	90	18.26	0.24	177.68	6.65	161.4-191.1
Southern Region	215	18.29	0.49	179.15	5.56	164.6-193.8
Total	830	18.25	0.45	179.52	5.96	161.4-198.8

Analysis of the average body heights of female subjects is shown in Table 2. The mean of body height for the overall sample of female subjects is 165.72±4.93 centimetres, while the tallest female subjects live in the central region of Kosovo (166.77±4.72 cm), the medium ones live in the western region (166.33±5.36 cm), shorter ones in the northern region (165.36±4.56 cm), those shorter than them in the southern region (165.29±4.60 cm), and the shortest ones live in the eastern region (164.10±4.61 cm) of Kosovo.

TABLE 2 Descriptive statistics among female subjects

Municipality/Region	N	Age		Body Height		
		Mean	SD	Mean	SD	Range
Deçan	68	18.29	0.46	166.39	5.60	157.8-181.8
Ferizaj	79	18.13	0.33	165.22	4.81	158.2-177.5
Gjakovë	63	18.17	0.38	165.78	3.96	159.3-177.9
Gjilan	100	18.17	0.38	164.10	4.61	153.3-173.4
Istog	68	18.29	0.52	166.42	5.38	157.0-178.7
Junik	38	18.32	0.47	166.59	6.25	157.2-181.3
Mitrovicë	90	18.29	0.46	165.36	4.56	158.7-182.0
Pejë	89	18.22	0.42	166.22	5.23	153.3-180.7
Prishtinë	93	18.15	0.36	166.77	4.72	157.3-185.0
Prizren	105	18.36	0.50	165.34	4.46	158.0-184.0
Northern Region	90	18.29	0.46	165.36	4.56	158.7-182.0
Western Region	225	18.21	0.41	166.33	5.36	153.5-181.8
Central Region	93	18.15	0.36	166.77	4.72	157.3-185.0
Eastern Region	100	18.17	0.38	164.10	4.61	153.3-173.4
Southern Region	184	18.26	0.45	165.29	4.60	158.0-184.0
Total	793	18.24	0.43	165.72	4.93	163.3-185.0

DOI 10.26773/mjssm.190310

Discussion

This research contributes to an update on adult human heights among subjects of both sexes in Kosovo, both globally and partially per administrative regions. The contribution is evident due to the lack of relevant data from previous research in this area, and the fact that a global study carried out by NCD Risk Factor Collaboration (2016) failed to include in its analyses the trend of changes in body height of the population of Kosovo. Consequently, the aforementioned study excluded Kosovans as well as a few other countries from this research, which analysed 1472 populations in 200 countries and comprised more than 18.6 million participants.

The results of this research study classify both males and females from Kosovo in a group of tall, but not the tallest nations in the world. The Kosovo males, with an average height of 179.52 centimetres, are not classified among the ten tallest nations in the world, but they are quite close to making the first ten due to a positive influence of the secular trend. If we classify the population living in the Dinaric Alps, the Kosovan males would be shorter than the 183.8 centimetres of the Bosnian and Herzegovinian male population (Gardasevic, Rasidagic, Krivokapic, Corluka, & Bjelica, 2017), the 183.36 centimetres of the Montenegrin male population (Popovic, 2017), the 182 centimetres of Serbian males (Popovic et al., 2013), the 180.5 centimetres of Croatian males (Juresa et al., 2012), or the 180.3 centimetres of Slovenian males (Starc & Strel, 2011). However, if we compare the average body height of males from Kosovo with the body heights of other nations, first of all with those in the region and wider, we observe interesting facts such as that the Kosovo male population is taller than the 178.1 centimetres of the Macedonian male population (Popovic, Bjelica, Georgijev, Krivokapic, & Milasinovic 2016), the 174 centimetres of Albanian males (Grasgrube, Cacek, Kalina, & Seberaet, 2014), the 178.8 centimetres of Austrian males (Hatton & Bray, 2010), the 177 centimetres of French males (Heroin, 2003), or the 178.1 centimetres of Greek males (Papadimitriou et al., 2008).

In contrast, the Kosovo female population, whose average height is 165.72 centimetres, is also one of the tallest nations in the world. If we classify the population living in the Dinaric Alps, the Kosovo female population is shorter than the 171.8 centimetres of the Bosnian and Herzegovinian females (Popovic et al., 2015), the 168.3 centimetres of the Montenegrin (Bjelica et al., 2012), the 167.4 centimetres of the Slovenians (Starc & Strel, 2011), the 166.8 centimetres of the Serbians (Popovic et al., 2013), or the 166.5 centimetres of the Croats (Juresa et al., 2012). Also, as in the case of the male populations, if we compare the average height of the Kosovo females with the average height of the other nations in the region and beyond, the results are intriguing. The female Kosovo population is taller than the 164.58 centimetres of the Macedonian females (Popovic et al., 2016), the 161.08 centimetres of Albanian females (Grasgrube et al., 2014), the 164.6 centimetres of French females (Herpin, 2003), the 162.5 centimetres of Italian females (Grasgrube et al., 2014), the 165.1 centimetres of Polish females (Kulaga et al., 2011), or the 161.9 of Turkish females (Iseri & Arslan, 2009). Data on both male and female populations of Kosovo clearly confirm its specific heights and the importance of answering the question related to the extremely high values of average body heights of populations living in the area of the Dinaric Alps, as well as the differences among the populations belonging to the same ethnic group living in Kosovo and Albania.

It is the conclusion of the authors of the current research that the average body height of both gender-based groups from Kosovo in this study does not represent the maximum potential that might be reached by the population of Kosovo. Specifically, subjects from this study were boys and girls born in 1998. This year is intriguing as many inhabitants from the neighbouring countries might remember, but to remind those living in other parts of Europe or the world, at the end of the 20th century the children born in 1998 were growing up in a period of war and great crises which led to poor socio-economic conditions, which were reflected in the quality of life, and consequently also human body height (Popovic, 2018). Based on this, it can be concluded that the population of Kosovo still has not reached its maximum genetic potential, and the secular trend has yet to be completed. In addition, it is realistic to expect that the coming generations will reach a height that will place them among the world's tallest nations. Thus, the new generations will face a whole range of questions regarding the value of body height, all earlier discussed in detail.

The average body height of an overall population is interesting when comparing nations. However, this study carries another, rather more interesting analysis that indicates differences among geographic areas of the Dinaric Alps and other mountain ranges where, as a rule, the tallest people in the world live.

The population of the central region is the tallest (180.62 cm), which was unexpected but logical. The authors of this study did not expect to find the tallest subjects in the central region, as it is not situated in the Dinaric Alps, which is most probably due to migrations from other parts of Kosovo towards the capital city in recent decades, since the capital city offered better economic and living conditions. Still, more attention should be paid to better living conditions than to migrations, as there is no available data. However, it can be assumed that people migrated from both Dinaric and other regions, so these results are explained by the secular trend in the central region where Pristina, the capital city of Kosovo, is situated. Therefore, the capital city should be omitted from future analysis due to the previously mentioned facts, which are interfering with the hypotheses of this study. On the second, third and fourth places are, from the tallest to the shortest people, the northern (180.29 cm), western (179.89 cm) and southern region (179.15 cm), all positioned in the Dinaric Alps, which conforms with the assumptions made by the authors. This represents evidence that the inhabitants from the Dinaric Alps belong to an extremely tall population as far as the average height is concerned. However, it

is also noteworthy to point out that the eastern parts of the Northern and Southern Region are not entirely positioned in the Dinaric Alps, so a more detailed image of the situation might be obtained by implementing a national survey of the entire population of Kosovo, and not only on a representative sample as in this study. Nevertheless, the rest of the region should also be included. This is the eastern region where the shortest males in Kosovo (177.68 cm) live, and it is not near the Dinaric Alps whatsoever.

In contrast, regarding the female population of Kosovo, the results are quite similar. The highest values of the average body height were determined for female subjects from the Central Region (166.77 cm), while on the second, third and fourth places are the western (166.33 cm), northern (165.36 cm) and southern region, (165.29 cm), all positioned in the Dinaric Alps, while the shortest female subjects live in the eastern region (164.10 cm). Results obtained for the female population indicate similar conclusions regarding the hypotheses as in the case of the male population.

Even though not all municipalities of Kosovo were available, it is worth to analysing the available ones as an introduction to a new and more detailed study, which might include the overall population. As far as the average body heights per municipalities are concerned, the variation is more expressed in male subjects (2.94 cm) in relation to female subjects for which the range from the minimum to maximum value is slightly lower (2.67 cm). Accordingly, the average body height ranges from 177.68 centimetres in the municipality of Gjilan to 180.62 centimetres in the municipality of Pristina for male subjects, and from 164.1 centimetres to 166.77 centimetres in the respective municipalities for female subjects. Estimation of the average body height according to municipality makes sense only if it could provide a clearer idea for analysing parts of the northern and eastern region as they are not situated in the Dinaric Alps entirely. The available analysis of the average body height values per municipalities is shown in detail in Table 1 for male subjects and in Table 2 for female subjects. In this part of the discussion the authors had no possibility of carrying out a more specific analysis of the narrow local areas, firstly due to the fact they only had limited data available. However, the authors included the available data, even though they knew the limitations, as they considered it could be beneficial for future research and consequently lead to collecting data that might be useful for drawing eagerly expected conclusions on determining carefully the value of the average body height in the population from the municipalities from the northern and southern region, situated in the Dinaric Alps, as well as in the population from the municipalities of the regions not situated in the Dinaric Alps.

Besides the average body height analysed on the overall sample, and on the subsamples of subjects per regions, it is interesting to analyse the density of very tall and very short subjects, particularly because a high value of very tall subjects is characteristic of the population of Kosovo's neighbours. The aim was to summarize the gathered information, which is quite important for the process of talent identification in certain sports disciplines. The density of very tall male subjects is not characteristic of the population of Kosovo since not even one of the subjects was above 200 centimetres, and only 5% of subjects were above 190 centimetres. Accordingly, the density of very tall male subjects in Kosovo has still not reached the results determined by Pineau et al. (2005) for the Dinaric Alps population, which is reflected in 28% of subjects taller than 190 centimetres. Still, it can be noticed that there are significantly more tall subjects in Kosovo (190 centimetres and above) than in France where the percentage is 1% (Pineau et al., 2005). It is interesting to point out that there were no subjects shorter than 160 centimetres, while there was only a small number of those shorter than 170 centimetres at the level of the entire nation (4.6%). The greatest percentage of extremely short subjects was

TABLE 3 Density of very short and very tall male subjects

Municipality/Region	Below 160 cm (%)	Below 170 cm (%)	Above 190 cm (%)	Above 200 cm (%)
Deçan	0	8.2	8.4	0
Ferizaj	0	2.1	3.3	0
Gjakovë	0	3.3	8.0	0
Gjilan	0	12.2	4.4	0
Istog	0	3.6	5.4	0
Junik	0	6.6	0	0
Mitrovicë	0	1.1	4.6	0
Pejë	0	2.2	5.5	0
Prishtinë	0	0	8.0	0
Prizren	0	6.7	2.5	0
Northern Region	0	1.1	4.6	0
Western Region	0	3.9	6.5	0
Central Region	0	0	8.0	0
Eastern Region	0	12.2	4.4	0
Southern Region	0	11.4	2.8	0
Total	0	4.6	5.0	0

DOI 10.26773/mjssm.190310

found in the municipality of Gjilana (6.7%), which is situated in the eastern part of Kosovo, an area furthest from the Dinaric Alps. A significant percentage of extremely short subjects was also found in the municipality of Prizren (6.7%), also situated in the east, which confirms the hypothesis on differences in body composition of the inhabitants living in the Dinaric Alps, and those beside them.

In contrast, the municipality of Decani that is situated in the Dinaric Alps is rather interesting for observation since in this area it has been determined that 8.2% of subjects have an average body height of 170 centimetres or below, which is unexpected since a density of subjects measured 190 centimetres and taller (8.4%) has been determined in the same municipality. In accordance with this fact, the average height of male subjects from the previously mentioned municipality exceeds the average values of the entire Kosovo population (179.66 cm), but this fact should be taken with caution since detailed analyses of the subsamples indicate certain unexpected variations, preventing us from claiming that the population of the Dinaric Alps is unconditionally the world's tallest. Detailed analysis of the density of extremely tall and extremely short subjects is shown in Table 3.

As in the case of the male population, the density of the female population is not characteristic of the Kosovo female population, considering there was not even one female subject taller than 190 centimetres, and only 1.2% of female subjects were taller than 180 centimetres. It is also noteworthy that a percentage of extremely tall female subjects were established in two municipalities from the area of the Dinaric Alps in the west of Kosovo. These are the municipalities of Junik with 5.3% and Decani with 2.9% of female subjects with 180 centimetres or more. In the municipalities of Ferizaj and Gjilan, which are positioned in the eastern part of Kosovo, not even one female subject was taller than 180 centimetres. This was also the case of the municipalities of Gjakova and Istog, which is surprising as they gravitate towards the area that is considered to have an impact of high values of the density of tall female subjects. However, a detailed analysis is given in Table 4, and it can significantly contribute to experts from the area of sport for providing realistic expectations in the process of talent identification among girls.

TABLE 4 Density of very short and very tall female subjects

Municipality/Region	Below 150 cm (%)	Below 160 cm (%)	Above 180 cm (%)	Above 190 cm (%)
Deçan	0	7.4	2.9	0
Ferizaj	0	15.2	0	0
Gjakovë	0	1.6	0	0
Gjilan	0	25.0	0	0
Istog	0	11.8	0	0
Junik	0	18.4	5.3	0
Mitrovicë	0	8.9	1.1	0
Pejë	0	10.1	1.1	0
Prishtinë	0	3.2	1.1	0
Prizren	0	8.6	1.0	0
Northern Region	0	8.9	1.1	0
Western Region	0	12.0	1.3	0
Central Region	0	3.2	1.1	0
Eastern Region	0	25.0	0	0
Southern Region	0	11.4	0.5	0
Total	0	11.0	1.2	0

Finally, it is necessary to emphasize that the ongoing trend indicating that the populations living in the area of the Dinaric Alps are the tallest in the world is still active. However, these speculations should be avoided, giving future studies solid foundations for global research to have these conclusions, which seem possible in light of this study. Therefore, it is recommended that further research should be first oriented towards implementation of national surveys in countries from the area of the Dinaric Alps, especially because such research might provide detailed analyses if later needed. In addition, this is the main limitation of this study, as the authors had no possibility of determining differences on the micro level, which needed this as the sample of subjects was constructed as a representative sample of the administrative regions of Kosovo. Altogether, this study provided a clear and quality contribution to contemporary anthropology, representing a quality addition to the previous global studies, which failed to include the population of Kosovo in their research.

REFERENCES

Arifi, F., Bjelica, D., Sermaxhaj, S., Gardasevic, J., Kezunovic, M., & Popovic, S. (2017). Stature and its Estimation Utilizing Arm Span Measurements in Kosovan Adults: National Survey. *International Journal of Morphology*, *35*(3), 1161-1167. doi: 10.4067/S0717-95022017000401316

Bjelica, D., Popovic, S., Kezunovic, M., Petkovic, J., Jurak, G., & Grasgruber, P. (2012). Body Height and Its

Estimation Utilizing Arm Span Measurements in Montenegrin Adults. *Anthropological Notebooks, 18*(2), 69–83.

Coon, C. (1939). *The races of Europe.* New York: Macmillan Publishers.

Coon, C. (1970). *The mountains of giants.* Papers of the Peabody Museum of American Anthropology. New York: Kraus Reprint Co.

Gardasevic, J., Rasidagic, F., Krivokapic, D., Corluka, M., & Bjelica, D. (2017). Stature and Its Estimation Utilizing Arm Span Measurements in Male Adolescents from Herzeg-Bosnia Entity in Bosnia and Herzegovina. *Montenegrin Journal of Sports Science and Medicine, 6*(1), 37-44.

Grasgruber, P., Cacek, J., Kalina, T., & Seberaet, M. (2014). The role of nutrition and genetics as key determinants of the positive height trend. *Economics & Human Biology, 15*, 81-100. doi: 10.1016/j.ehb.2014.07.002

Grgantov, Z., Padulo, J., Milić, M., Ardigò, L.P., Erceg, M., & Cular, D. (2017). Intra-Positional and Inter-Positional Differences in Somatotype Components and Proportions of Particular Somatotype Categories in Youth Volleyball Players. *Annals of Applied Sport Science*, 5(2), 37-49. doi: 10.18869/acadpub.aassjournal.5.2.37

Hatton, T.J., & Bray, B.E. (2010). Long run trends in the heights of European men, 19th-20th centuries. *Economics and human biology, 8*(3), 405-413. doi: 10.1016/j.ehb.2010.03.001

Herpin, N. (2003). La taille des hommes: son incidence sur la vie en couple et la carrière professionnelle. *Economie et Statistique, 361*(1), 71–90.

Iseri, A., & Arslan, N. (2009). Obesity in adults in Turkey: age and regional effects. *European Journal of Public Health, 19*(1), 91–94. doi: 10.1093/eurpub/ckn107

Juresa, V., Musil, V., & Tiljak, M.K. (2012). Growth charts for Croatian school children and secular trends in past twenty years. *Collegium Antropologicum, 36*(1), 47-57.

KFOR_Structur.2006 [PNG] (2006). Retrieved from https://upload.wikimedia.org/wikipedia/commons/c/ce/KFOR_Structur.2006.PNG

Kułaga, Z., Litwin, M., Tkaczyk, M., Palczewska, I., Zajączkowska, M., Zwolińska, D., Krynicki, T., Wasilewska, A., Moczulska, A., Morawiec-Knysak, A., Barwicka, K., Grajda, A., Gurzkowska, B., Napieralska, E., & Pan, H. (2011). Polish 2010 growth references for school-aged children and adolescents. *European Journal of Pediatrics, 170*(5), 599–609. doi: 10.1007/s00431-010-1329-x

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.

Masanovic, B., Milosevic, Z., & Corluka, M. (2018). Comparative Study of Anthropometric Measurement and Body Composition between Junior Handball and Volleyball Players from Serbian National League. *International Journal of Applied Exercise Physiology, 7*(4), 1-6. doi: 10.30472/ijaep.v7i4.313

NCD Risk Factor Collaboration (2016). A century of trends in adult human height. eLife, 5:e13410. doi: 10.7554/eLife.13410.

Papadimitriou, A., Fytanidis, G., Douros, K., Papadimitriou, D.T., Nicolaidou, P., & Fretzayas, A. (2008). Greek young men grow taller. *Acta Paediatrica, 97*(8), 1105–1107. doi: 10.1111/j.1651-2227.2008.00855.x

Pineau, J.C., Delamarche, P. & Bozinovic, S. (2005). Average height of adolescents in the Dinaric Alps (in French). *Comptes Rendus Biologies, 328*(9), 841–846. doi: 10.1016/j.crvi.2005.07.004

Popovic, S. (2017). Local Geographical Differences in Adult Body Height in Montenegro. *Montenegrin Journal of Sports Science and Medicine*, *6*(1), 81-87.

Popovic, S. (2018). Arm-span measurement as an alternative estimation of true height in Montenegrin young adults of both sexes: A national survey. *Anthropological Notebooks, 24*(1), 53–67.

Popovic, S., Arifi, F., & Bjelica, D. (2017). Standing Height and its Estimation Utilizing Foot Length Measurements in Kosovan Adults: National Survey. *International Journal of Applied Exercise Physiology*, 6(2), 1-7. doi: 10.22631/ijaep.v6i2.150

Popovic, S., Bjelica, D., Georgijev, G., Krivokapic, D., & Milasinovic, R. (2016). Body Height and its Estimation Utilizing Arm Span Measurements in Macedonian Adults. *The Anthropologist, 24*(3), 737-745. doi: 10.1080/09720073.2016.11892070

Popovic, S., Bjelica, D., Molnar, S., Jaksic, D., & Akpinar, S. (2013). Body Height and Its Estimation Utilizing Arm Span Measurements in Serbian Adults. *International Journal of Morphology, 31*(1), 271-279. doi: 10.4067/S0717-95022013000100043

Popovic, S., Bjelica, D., Tanase, G.D., & Milasinovic, R. (2015). Body Height and Its Estimation Utilizing Arm Span Measurements in Bosnian and Herzegovinian Adults. *Montenegrin Journal of Sports Science and Medicine, 4*(1), 29-36.

Quanjer, P.H., Capderou, A., Mazocioglu, M.M., Aggarwal, A., Popovic, S., Datta Banik, S., Tayie, F.A.K., Golshan, M., Ip, M.S.M., Zelter, M. (2014). All-age relationship between arm span and height in different ethnic groups. *European Respiratory Journal, 44*(4), 905-912. doi: 10.1183/09031936.00054014

Starc, G., & Strel, J. (2011). Is there a rationale for establishing Slovenian body mass index references of school-aged children and adolescents? *Anthropological Notebooks, 17*(3), 89-100.

Stoop, R., Hohenauer, E., Rucker, M.L.A., Clijsen, R. (2018). Anthropometric Properties versus Physical Performance in Rugby ::union:: Forwards and Backs - A Systematic Review. *Annals of Applied Sport Science*, 6(2), 1-13. doi: 10.29252/aassjournal.6.2.1

Zoom into Dinaric Alps mountain range [PNG] (2017). Retrieved from https://www.motionelements.com/stock-video-9696376-zoom-into-dinaric-alps-mountain-range-glowed-colored-physical-map

DOI 10.26773/mjssm.190310

Guidelines for Authors

Revised September 2017

*** 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 *Montenegrin Journal of Sports Science and Medicine* (MJSSM) applies the Creative Commons Attribution (CC BY) license to articles and other works it publishes.

There is no charge for submissions and no page charge for accepted manuscripts. However, if the manuscript contains graphics in color, note that printing in color is charged.

MJSSM 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.

MJSSM honors a 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. English standard should be consistent throughout the manuscripts.

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

MJSSM 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 MJSSM.

☑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 MJSSM editorial board. MJSSM 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

MJSSM only accepts electronic submission to the e-mail of the Journal Office: **office@mjssm.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 MJSSM, 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

An original 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 MJSSM;
- 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 MJSSM.

The editors-in-chief, executive editor 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.

MJSSM 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, executive editor 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

MJSSM applies the Creative Commons Attribution (CC BY) license to articles and other works it publishes. If author(s) submit its paper for publication by MJSSM, 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 MJSSM 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, MJSSM 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, MJSSM 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. MJSSM 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. MJSSM 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 MJSSM 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 MJSSM. 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.

MJSSM 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 MJSSM 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 MJSSM. 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 **office@mjssm.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

MJSSM 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:

Transfer of Learning on a Spatial Memory Task between the Blind and Sighted People Spatial Memory among Blind and Sighted

Original Scientific Paper

Transfer of learning on a spatial memory task

Selcuk Akpinar[1], Stevo Popović[1,2], Sadettin Kirazci[1]

[1]Middle East Technical University, Physical Education and Sports Department, Ankara, Turkey
[2]University of Montenegro, Faculty for Sport and Physical Education, Niksic, Montenegro

Corresponding author:
S. Popovic
University of Montenegro
Faculty for Sport and Physical Education
Narodne omladine bb, 84000 Niksic, Montenegro
E-mail: stevop@ac.me

Word count: 2,980

Abstract word count: 236

Number of Tables: 3

Number of Figures: 3

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), and Title and Abstract in Montenegrin (only for the authors from former Yugoslavia, excluding Macedonians and Slovenes). 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

MJSSM 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

MJSSM 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. MJSSM 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 MJSSM.

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%	✓ 10°	✓ 10 kg	✓ 12:2	✓ 0.056
× 10 %	× 10 °	× 10kg	× 12 : 2	× .056

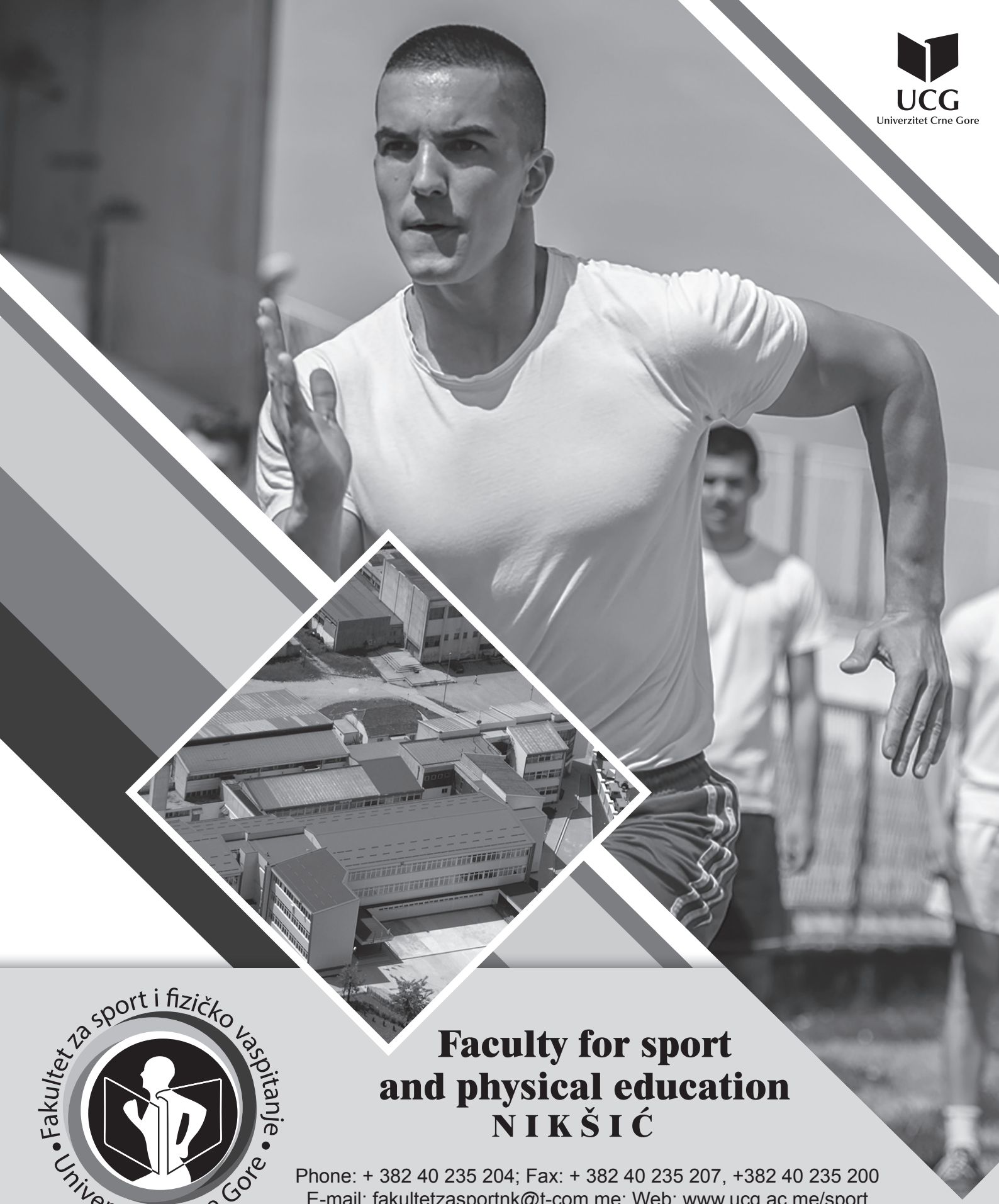
Signs should be placed immediately preceding the relevant number.		
✓ 45±3.4	✓ p<0.01	✓ males >30 years of age
× 45 ± 3.4	× p < 0.01	× males > 30 years of age

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*



UCG
Univerzitet Crne Gore

Fakultet za sport i fizičko vaspitanje
Univerzitet Crne Gore

Faculty for sport and physical education
N I K Š I Ć

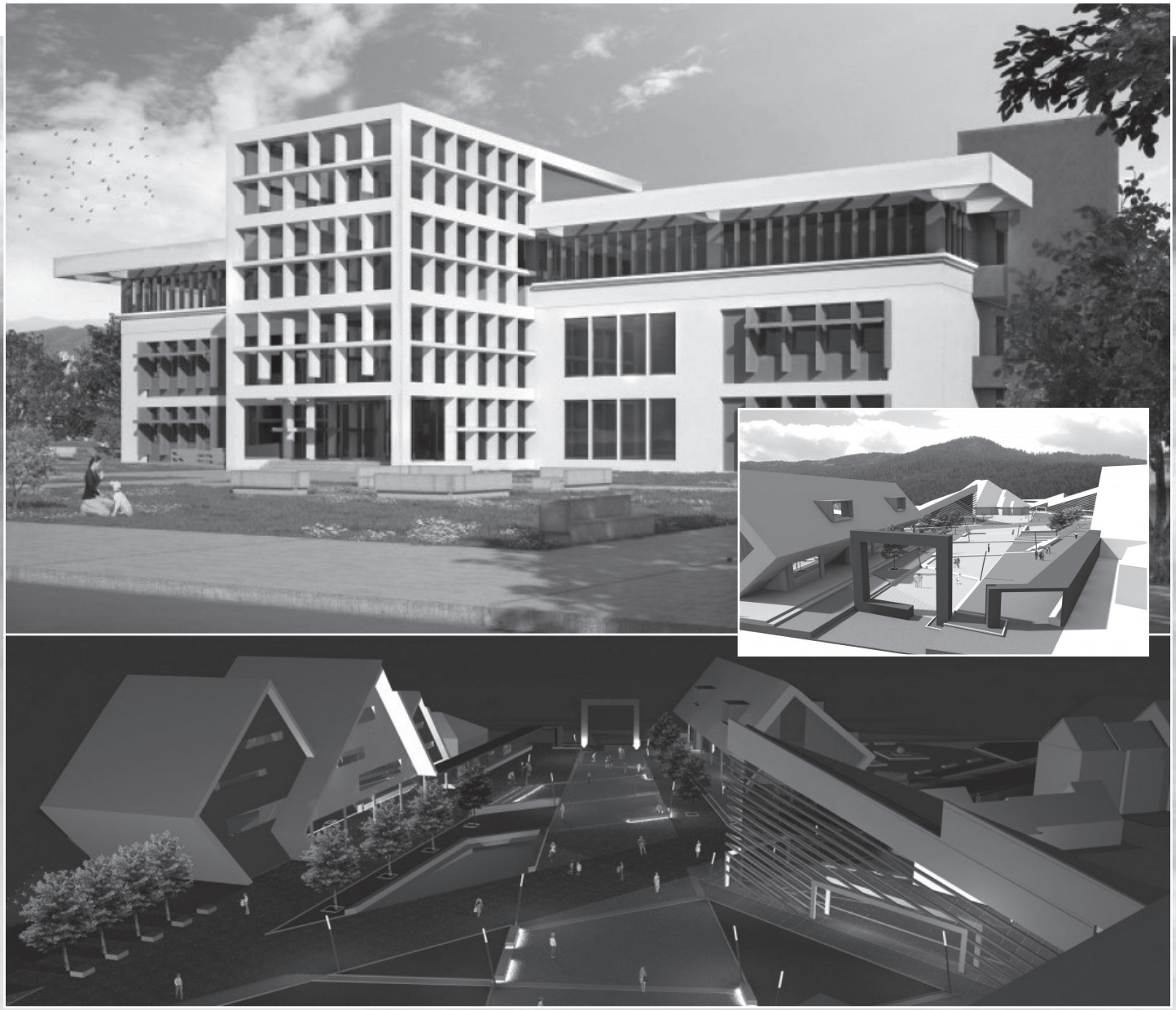
Phone: + 382 40 235 204; Fax: + 382 40 235 207, +382 40 235 200
E-mail: fakultetzasportnk@t-com.me; Web: www.ucg.ac.me/sport

Znanje i zdravlje!

UCG
Univerzitet Crne Gore

UNIVERZITET CRNE GORE
ARHITEKTONSKI FAKULTET

UNIVERSITY OF MONTENEGRO
FACULTY OF ARCHITECTURE



The goal of establishment of our institution is the education highly qualified professional cadre based on the best knowledge of the theory and practice in the world, and its application to the development and implementation of plans and projects in the space - as a basic condition for the quality valorization, programming, management and protection of natural and inherited built environment. In this way conceptualized school forms internationally experts in all areas of creativity - in the field of urban planning, architecture, construction and design - which includes the ability to create useful objects, architectural forms of all categories, urban and vacant space at different levels. Such qualified cadre are the spiritus movens of development of culture and technology in the modern world.

Bulevar Džordža Vašingtona bb
81000 Podgorica, Montenegro
Tel +382 20 269 262
Fax +382 20 81 269 317

We follow the highest academic and professional standards

arhitektura@ac.me
www.ucg.ac.me/af

UNIVERZITET CRNE GORE
FAKULTET ZA POMORSTVO – KOTOR

UNIVERSITY OF MONTENEGRO
MARITIME FACULTY - KOTOR

In addition to maritime education in navigation and marine engineering, University of Montenegro - Maritime Faculty in Kotor also provides additional training for professional seafarers in:

- Different IMO model courses
- DP - Dynamic positioning courses
- Offshore courses

From 2015 runs the newly established joint training center with partners from NTNU - Aallesund in Norway, being one of the most experienced and most successful in providing offshore and DP training courses worldwide. The up-to-date bridge simulator, accompanied by AB simulations and instructor station, enables the organization of all the courses held as in the Norwegian training centers, with the same team of instructors and certificates. So far, a series of courses have been organized related to the operation of complex offshore equipment and team work in these demanding operations, both for students and international crews. In addition, the Kotor/Aalesund training center has recently been awarded with the Nautical Institute accreditation for holding DP (Induction and Simulator) trainings and so far has successfully launched several groups of DP operators.

OSC offshore simulator at Maritime Faculty Kotor, Montenegro

Dobrota 36, 85330 Kotor
Tel/Fax ++382(0)32 - 303 - 184
Centrala ++382(0)32 - 303 - 188
fzp@ac.me, www.ucg.ac.me/pfkotor

Ž.R. 510-227-38
PIB 02016702
PDV 30/31-03951-6

UCG
Univerzitet Crne Gore

UNIVERZITET CRNE GORE
PRAVNI FAKULTET – PODGORICA

UNIVERZITET CRNE GORE
PRAVNI FAKULTET PODGORICA

Faculty of Law was founded on October 27th, 1972 in Podgorica as a scientific and artistic educational institution, in which educational and research work was organized in the area of law and similar social studies. While making into law the establishment of this institution, Assembly of Socialistic Republic of Montenegro highlighted that "The establishment of this institution of high education is necessary for meeting overall demands of the society of the Republic". Faculty of Law is one of the founding fathers of the University of Montenegro.

During the forty-five years of its existence Faculty of Law grew to a modern, contemporary, scientific and artistic educational institution. Forty-five generations studied at the faculty. About 17.000 students enrolled at the faculty and 4285 students graduated from the faculty. About 15 percent of the students studied abroad. Part of the best students continued postgraduate and doctoral studies at prominent university centers. Most of the former students stayed in Montenegro due to family ties. 88 professors and associates worked at the faculty, out of whom there were 26 guest professors. Today most of the professors and cadre at the faculty are former students.

Faculty organizes graduate and postgraduate studies. There are teaching and cadre resources for organizing specialist and doctoral studies in all the areas of law.

As a university branch Faculty of Law realizes a big number of its planned aims and tasks and finds soulutions for many important questions of cadre organization, technical and material problems. With the help of the University of Montenegro, faculty largely develops the international coorporation net.

Faculty follows world trends and achievements in the area of high education with the aim to coordinate its work with European and world demands. This year faculty made the first steps in realization of Bologna declaration. There is enough cadre for all the necessary teaching at the faculty.

The faculty was founded because of expression of need to reach the neccessary standard for socio-economic, political, cultural and social development of Montenegro. During its overall existence faculty shared the fate with Montenegrin society. It will continue to do so by making steps towards implementing new practises and creating new relations, with the help of implementatation of modern European trends.

The faculty is a complex organization and managing institution nowadays.

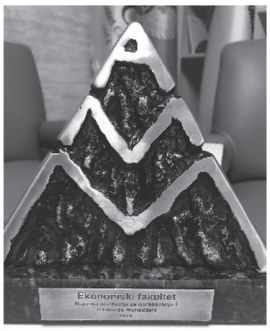
University of Montenegro
FACULTY of ECONOMICS PODGORICA

UCG
University of Montenegro

Faculty of Economics
University of Montenegro

The Faculty of Economics celebrated its 57th anniversary this year, and it is the oldest higher education institution in the country. Since its establishment, 8,630 students graduated at our Faculty.

Today, Faculty of Economics is a largely interdisciplinary institution, characterized by expressed dynamism in its work. Employees at the Faculty are dedicated to constant improvements and enhancements, all in accordance with the needs brought by the changes.



We provide our students with the best theoretical and practical knowledge, enabling them to develop critical spirit in approaching economic phenomena and solving concrete problems in daily work. From September 2017, at the Faculty, the new generation will start a 3 + 2 + 3 study, which will improve the quality of studying.

Development of Faculty of Economics in the coming period will follow the vision of development of the University of Montenegro, pursuing full achievement of its mission

Comprehensive literature, contemporary authors and works have always been imperative in creation of new academic directions at Faculty of Economics, which will form the basis of our future.

Faculty and its employees are dedicated to developing interest in strengthening the entrepreneurial initiative, creative and interdisciplinary approach among young people, using modern teaching and research methods. In this regard, the Faculty has modern textbooks and adequate IT technology, which supports the objectives set.

Jovana Tomaševića 37
81000 Podgorica, Montenegro

www.ekonomija.ac.me
ekonomija@ac.me

Phone: + 382 20 241 138
Fax: + 382 20 244 588

University of Montenegro

Cetinjska br.2
81 000 Podgorica
Montenegro

E-mail:
rektor@ac.me
rektorat@ac.me

Phone: + 382 20 414 255
Fax: + 382 20 414 230

Web:
www.ucg.ac.me

The University of Montenegro is the leading higher education and research institution in Montenegro. It is a public institution, established by the state, operating as a unique legal entity represented by the Rector. It is an integrated university organized on the model of the most European universities. Organizational units are competent for provision of study programmes, scientific-research and artistic work, use of allocated funds and membership in professional associations.

Since its foundation, the University of Montenegro has continuously been conducting reforms in the area of education and research, while since 2003 in line with the trends in EHEA. After adoption of the Bologna Declaration, University of Montenegro organized systematic preparation of documents aligned with it. Already in 2003, the experimental teaching programme started and today, all studies are organised in line with the Bologna principles. During the last two years systematic reforms of the University`s study programes have been conducted in order to harmonize domestic higher education system with European standards and market needs to highest extent.

The University of Montenegro has unique academic, business and development objectives. It comprises 19 faculties and two research institutes. The seat of the UoM is in Podgorica, the capital city, while university units are located in eight Montenegrin towns. The University support services and centers (advisory services, accounting department, international cooperation, career orientation) are located in the Rectorate.

Academic community of University of Montenegro is aware of the importance of its functioning for further development of the state and wider region. It has been so far, and will be in the future, the leader in processes of social and cultural changes, along with the economic development.

In the aspect of attaining its mission, University of Montenegro is oriented towards the priority social needs of the time in which it accomplishes its mission; open for all the students and staff exclusively based on their knowledge and abilities; dedicated to preservation of multicultural and multi-ethnic society in Montenegro; entrepreneurial in stimulating social and economic application of supreme achievements within the scope of its activities.

In 2015/16 there were a total of 1.192 employees at UoM, 845 of which were engaged in teaching. In the same year there were 20.236 students registered at all three cycles of studies.

Internationalization is high on the agenda of UoM priorities, thus it has participated in a number of international projects – over 50 projects funded under the Tempus programme, over 15 Erasmus Mundus Action 2 projects for student mobility, a number of projects under FP7 funding scheme or IPA supported projects, Erasmus + capacity building and International credit mobility projects and other.

For more information about University of Montenegro, please visit our website www.ucg.ac.me or send e-mail to pr.centar@ac.me.

UCG
Mašinski fakultet
Podgorica

UNIVERSITY OF MONTENEGRO
FACULTY OF MECHANICAL ENGINEERING
Podgorica

www. ucg.ac.me/mf

Mechanical engineering studies in Montenegro started during the school year 1970/71. On April 15th, within the Technical Faculty, the Department of Mechanical Engineering was formed. The Department of Mechanical Engineering of the Technical Faculty was transformed in 1978 into the Faculty of Mechanical Engineering, within the University "Veljko Vlahović". Since 1992 the Faculty of Mechanical Engineering is an autonomous University unit of the University of Montenegro. It is situated in Podgorica.

The University of Montenegro is the only state university in the country, and the Faculty of Mechanical Engineering is the only faculty in Montenegro from the field of mechanical engineering.

Activities of the Faculty of Mechanical Engineering can be divided into three fields: teaching, scientific-research work and profes- sional work.

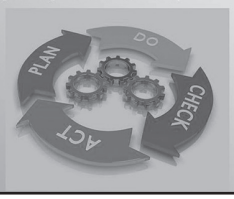
Two study programmes were accredited within the Faculty of Mechanical Engineering:

- Academic study programme MECHANICAL ENGINEERING
- Academic study programme ROAD TRAFFIC

The study programmes are realised according to the Bologna system of studies in accordance to the formula 3+2+3.

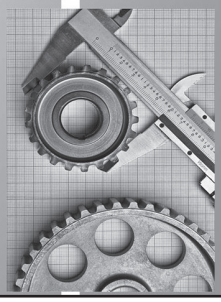
On the study program Mechanical Engineering it is possible to study next modules:

- Mechanical Engineering – Production
- Applied Mechanics and Construction
- Energetics
- Energy Efficiency
- Mechatronics
- Quality



At the Faculty of Mechanical Engineering, as organisational units, there are centres and laboratories through which scientific-re- search and professional work is done:

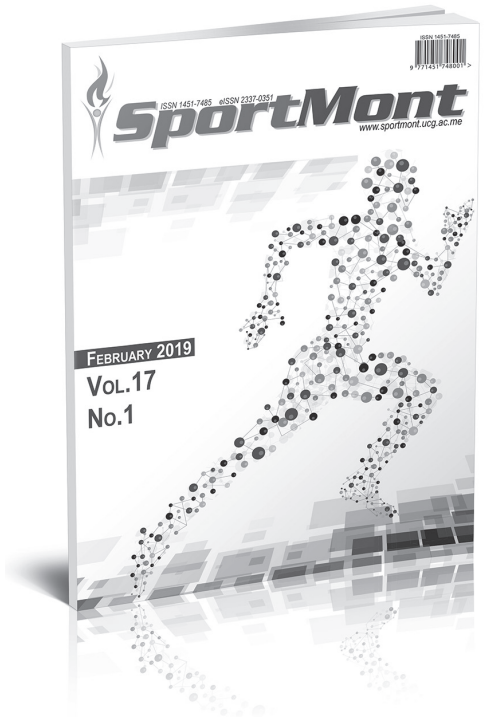
- Centre for Energetics
- Centre for Vehicles
- Centre for Quality
- Centre for Construction Mechanics
- Centre for Traffic and Mechanical Engi- neering Expertise
- Centre for transport machines and metal constructions
- 3D Centre
- Didactic Centre – Centre for Automation and Mechanomics training
- European Information and Innovation Centre
- Cooperation Training Centre
- Laboratory for Metal Testing
- Laboratory for Turbulent Flow Studies
- Laboratory for Vehicle Testing
- Laboratory for Attesting of Devices on the Technical Examination Line



CRNOGORSKI OLIMPIJSKI KOMITET
MONTENEGRIN OLYMPIC COMMITTEE

BE PART OF OUR TEAM

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



ISSN 1451-7485

Sport Mont Journal (SMJ) 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.

SMJ is published three times a year, in February, June and October of each year. SMJ 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.

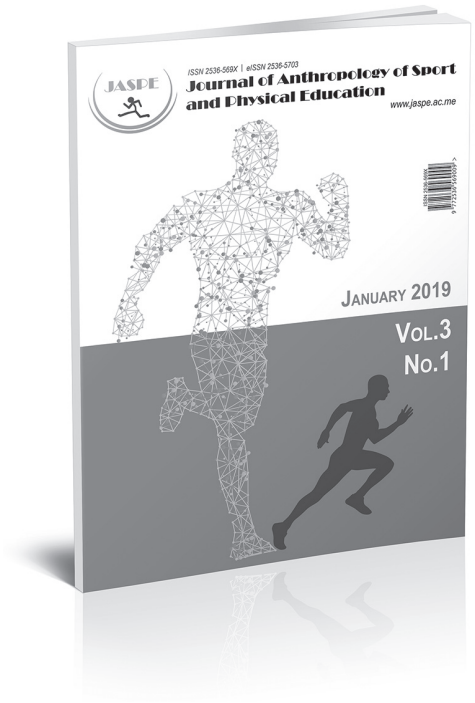
SMJ covers all aspects of sports science and medicine; all clinical aspects of exercise, health, and sport; exercise physiology and biophysical investigation of sports performance; sport biomechanics; sports nutrition; rehabilitation, physiotherapy; sports psychology; sport pedagogy, sport history, sport 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 SMJ website: http://www.sportmont.ucg.ac.me/?sekcija=page&p=51. Contributors are urged to read SMJ's guidelines for the authors carefully before submitting manuscripts. Manuscripts submissions should be sent in electronic format to sportmont@ac.me or contact following Editors:

Dusko BJELICA, *Editor-in Chief – dbjelica@ac.me*
Zoran MILOSEVIC, *Editor-in Chief – zoranais@eunet.rs*
Jovan GARDASEVIC, *Managing Editor – jovan@ac.me*

Publication date: Summer issue – June 2019
Autumn issue – October 2019
Winter issue – February 2020

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@ac.me or contact JASPE's Editor:

Bojan MASANOVIC, *Editor-in Chief – bojanma@ac.me*

Publication date: Spring issue – April 2019
Summer issue – July 2019
Autumn issue – October 2019
Winter issue – January 2020

USEFUL CONTACTS

Editorial enquiries and journal proposals:
Dusko Bjelica
Stevo Popovic
Editors-in-Chief
Email: **office@mjssm.me**

Selcuk Akpinar
Executive Editor
Email: **office@mjssm.me**

Marketing enquiries:
Jovan Gardasevic
Marketing Manager
Email: **administration@mjssm.me**

Sports Science and Medicine Journals

from Montenegrin Sports Academy

We have expanded the quality of our journals considerably over the past years and can now claim to be the market leader in terms of breadth of coverage.

As we continue to increase the quality of our publications across the field, we hope that you will continue to regard MSA journals as authoritative and stimulating sources for your research. We would be delighted to receive your comments and suggestions, mostly due to the reason your proposals are always welcome.

Look Inside!

Sport Mont Journal

Editors-in-Chief: **Dusko Bjelica**, Montenegro; **Zoran Milosevic**, Serbia
Managing Editor: **Jovan Gardasevic**, Montenegro

Volume 17, 2019, 3 issues per year; Print ISSN: 1451-7485, Online ISSN: 2337-0351

Sport Mont Journal is a scientific journal that 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. SMJ is published three times a year, in February, June and October of each year. SMJ 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.

www.sportmont.ucg.ac.me

Montenegrin Journal of Sports Science and Medicine

Editors-in-Chief: **Dusko Bjelica**, Montenegro; **Stevo Popovic**, Montenegro
Executive Editor: **Selcuk Akpinar**, Turkey
Associate Editors: **Mehmet Uygur**, USA; **Catalina Casaru**, USA; and **Predrag Bozic**, Serbia

Volume 8, 2019, 2 issues per year; Print ISSN: 1800-8755, Online ISSN: 1800-8763

Montenegrin Journal of Sports Science and Medicine (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.

www.mjssm.me

CIP – Каталогизација у публикацији
Централна народна библиотека Црне Горе, Цетиње

796:61 (497.16)

MONTENEGRIN journal of sport science and medicine / urednik Duško Bjelica. – Vol. 1, no. 1 (2012) - . – Podgorica (Džordža Vašingtona 445) : Crnogorska sportska akademija, 2013 (Nikšić : Art grafika). – 30 cm

Polugodišnje.
ISSN 1800-8755 = Montenegrin journal of sports science and medicine (Podgorica)
COBISS.CG-ID 17824272

MSA Conference 2019

16th Annual Scientific Conference of Montenegrin Sports Academy "Sport, Physical Activity and Health: Contemporary Perspectives"

http://www.csakademija.me/conference/

CRNOGORSKA SPORTSKA AKADEMIJA
MONTENEGRIN SPORTS ACADEMY

4th - 7th April 2019,
Dubrovnik - Croatia